ENVIRONMENTAL APPRAISAL OF BORDER AREA VILLAGES OF PUNJAB

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DECLARATION

I, hereby declared that the presented work in the thesis entitled **“ENVIRONMENTAL APPRAISAL OF BORDER AREA VILLAGES OF PUNJAB**” in fulfilment of degree of **Doctor of Philosophy (Ph. D.)** is outcome of research work carried out by me under the supervision of **Dr. Neeta Raj Sharma**, working as **Professor and Senior Dean,** in the **School of Bioengineering & Biosciences** of **Lovely Professional University, Punjab, India**. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigators. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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CERTIFICATE

This is to certify that the work reported in the Ph.D. thesis entitled **"ENVIRONMENTAL APPRAISAL OF BORDER AREA VILLAGES OF PUNJAB"** submitted in fulfillment of the requirement for the award of degree of **Doctor of Philosophy (Ph.D.)** in the **Department of Botany**, is a research work carried out by **Amandeep Bhatti**, Registration No. **11815329**, is bonafide record of her original work carried out under my supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

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ABSTRACT

A village is the basic unit of development and progress of a nation. Villages need to be independent and holistically developed entities. Under sustainable development goals (SGDs) it is one of the goals to make the villages 'smart' especially in terms of social, economic and environment aspects. On a similar pattern, Government of India started a programme for Rural development called 'SAGY'-Sansad Aadrash Gram Yojana to bridge the gap between rural and urban living. Globally, some rural areas are present close to the international border and fall in the category of border villages. Presently, a study on the border villages of Punjab has been taken into consideration. It is an effort to evaluate these villages on the basis of social, economic and environmental aspects as these villages lag behind the main stream villages. Physico-chemical parameters analysed for the soil samples include soil texture, Electrical conductivity (EC), pH, Moisture Content (MC), Bulk Density (BD), organic carbon (OC), soil organic matter (SOM), total available phosphorus (TP), total nitrogen, potassium. Apart from this heavy metal analysis was also carried out for Selenium, Mercury, Cadmium, Iron, Nickle, Lead, Uranium, Arsenic and Chromium. Similarly different physico-chemical parameters of municipal supply and groundwater were analysed i.e. pH, EC, alkalinity, hardness, TDS along with the content of fluorides, nitrates, sulphates and magnesium. In addition to this, heavy metals like Selenium (Se), Arsenic (As), Cadmium (Cd), Nickle (Ni), Chromium (Cr), Lead (Pb), Uranium (U) and Mercury (Hg) were also analysed.

The soil samples from the area under investigation were found to be slightly alkaline with sandy to loam and clayey loam textured soils. The soils had good organic matter and organic carbon with moderate bulk density. The prevalent use of agro-chemicals in agriculture has affected the composition of the soils of these areas under focus. With reference to heavy metals, the soil samples had Selenium (Se), Arsenic (As), Uranium (U) and Magnesium (Mg) were present in the permissible limits. Municipal supply water samples had high electrical conductivity, sulphate and magnesium ions and hardness. The samples also possess heavy metals like Lead (Pb), Nickle (Ni), Uranium (U), Arsenic (As) and Iron (Fe) in the municipal as well as groundwater.

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“No one who achieves a success does so without acknowledging the help of others, the wise and confident acknowledge this help with gratitude”—Alfred N Whitehead

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Amandeep Bhatti

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LIST OF ABBREVIATIONS

Abbreviations	**Full Form**
pH	Potential of hydrogen
EC	Electric Conductivity
TDS	Total Dissolve Solids
TH	Total Hardness
TA	Total Alkalinity
MC	Moisture Content
BD	Bulk Density
SOM	Soil Organic Matter
SOC	Soil Organic Carbon
Mg	Magnesium
NO^-_3	Nitrate
SO^-_4	Sulphate
Cl^-	Chloride
F^-	Fluoride
N	Nitrogen
P	Phosphorus
K	Potassium
%	Per Cent
mg/l	Milligram per litre
mg/kg	Milligram per kilogram
µS/cm	Microns Siemens per centimetre
Ni	Nickle
Cd	Cadmium
As	Arsenic
Pb	Lead
Cr	Chromium
Zn	Zinc
Hg	Mercury
Ca	Calcium
BADP	Border Area Development Programme
SBM-G	Swachh Bharat Mission-Gramin

AAS	Atomic Absorption Spectroscopy
ICP-MS	Inductively Coupled Plasma – Mass Spectrophotometry
WHO	World Health Organization
USEPA	United States Environmental Protection Agency
EPA	Environmental Protection Agency
BIS	Bureau of Indian Standards
EDXRF	Energy Dispersive X-ray Fluorescence
MPLI	Metal pollution load index
Mn	Manganese
Cu	Copper
U	Uranium
Sb	Antimony
Fe	Iron
MPAES	Microwave Plasma Atomic Emission Spectroscopy
Co	Cobalt
HPI	Heavy Metal Pollution
Na	Sodium
BOD	Biochemical Oxygen Demand
DO	Dissolved Oxygen
TS	Total Solids
µg/l	Microgram per litre
Sq.km	Square kilometre
Km	Kilometre

CHAPTER 1

INTRODUCTION

Borders are geographical boundaries of political entities or legal jurisdiction and villages in the vicinity of borders are called border villages. Punjab has 553km long stretch of international border with Pakistan. The three border districts, Gurdaspur, Ferozepur and Amritsar, of the undivided Punjab have been further divided and now we have three new additional districts i.e., Pathankot, Tarn Taran and Fazilka making a total of six border districts altogether. All these districts lag in growth and progress due to several reasons. Nearness to the border, two rivers flowing across i.e. River Ravi and River Sutlej and a decade-long cross border terrorism are some of the major hurdles in development. Firstly, restricted visiting and working hours in the fields near the fence and ban on growing tall crops does not allow the farmers to progress, diversify crops and enhance their income. Secondly, the rivers and their distributaries which flow across the state especially in these border districts often wash away the crops during rainy season and floods. Thirdly, the long spell of terrorism has left this belt at the mercy of nature with no industrial development and hence no other avenues for better earning and lifestyle. This total border area of 6369.82 sq. km (approx.) is inhabited by a population of 7936818, as per 2011 census.

The regions of India that border Pakistan are more hostile than those that border other nations. There has been an increase in trans-border activities like smuggling, border crossers, illicit trade, drug trafficking and Pakistani spies (Singh, A., 2013). Hence more deployment of security personnel at the borders. Due to hostile nature of Indo-Pak relationship, the people living in border areas had been and are under psychological stress. They also face socio- economic problems as these areas are inaccessible and insecure due to border security and trans-border issues. Thus, these areas are distinct and need special attention. For an integrated & sustainable development, the process of planning and development holds a special importance in these habitations. To promote holistic development, there is a need for thorough planning that takes into account various factors such as socioeconomic, environmental, emotional & mental concerns. The role of people’s participation in solving the actual issues faced by these special areas should also be given weightage. Though these special geographical pockets of Punjab are not very backward, but they are still lagging behind and suffer at the social & economic fronts. (Singh, K. and Rangnekar, U.S., 2010)

The border belt of Punjab has suffered a huge economic as well as developmental loss (Bala, R & Krishna, G.,1982) after independence. Due to its close proximity to international border, wars with Pakistan and protracted periods of cross border terrorism, there has been uncertainty and security issues amongst all leading to loss of industrial development.

Due to border security reasons, ban on cultivation of tall crops is a major hindrance in crop and income diversification. Moreover, poor access to their farmlands, restricted visits at zero-line, fencing and transnational illicit activities have further compounded their problems (Sekhon, J.S., 2014).

Environmental Appraisal and Sustainable Development:

Natural resources and other living things that help in growth and development constitute the environment of an organism. An interaction between biotic and abiotic factors has great importance in terms of sustainability that focuses on the goals like

Poverty eradication, clean drinking water & sanitation, health and well-being of the people, quality education, clean and sustainable energy, sustainable agriculture & industrialization and good economic growth with work for all.

Sustainability and sustainable development have been the prime focus of the Rio Summit and Agenda 21. The core elements of eco-development have been to meet the essential human needs with participatory approach in order to create self -reliant entities (Purvis, B., *et al.*, 2019). The conceptualization of three pillars or domains i.e. social, economic and environment has been important dimension of sustainable development. The basic idea is to strike an integrated balance between these three domains. This three-dimensional paradigm has further been a part of the Earth Summit (UNCED 1992) which states that progress development towards sustainability can be evaluated by assessing changes in social, economic and environmental aspects.

1.1 Smart Village Concept & Sustainability

The smart village concept is an initiative to strengthen the rural areas through innovations, technology & digitalisation in order to strengthen the socio-economic fabric of the villages. The concept has been launched globally in 2017 and nationally in 2014 as Sansad Adarsh Gram Yojana.

Villages in Border areas of Punjab are not ‘Smart’ in the real sense. They fall short in a number of essential sectors, including transportation, roads, drinkable water, sanitation and education which are key Sustainable Development Goals (SGDs) set by United Nations. The lack of industrial development and marketing infrastructure has deprived the people of new employment opportunities and better income perspectives.

Also, a rise in unemployment among skilled, unskilled, educated, illiterate young people has been observed. There are no facilities in villages to enhance the skills of youth especially under state run skill development programmes. Thus, the demographic profile of the village population mainly comprises of unskilled labour. (Singh, K. and Rangnekar, U.S., 2010).

Rural development entails raising the standard of living for rural population. It aims to develop rural areas in aspects like socio-economic, technology, health and sanitation as well as to provide infrastructural facilities. It means providing rural dwellers an access to the necessities like clean water, education, transportation & communication and clean energy to make ‘Sansad Adarsh Grams’ or ‘Smart villages. Sansad Adarsh Gram Yojana (SAGY) is a rural development initiative that the Indian Prime Minister unveiled on October 11, 2014 (SAGY, 2014).

1.2 Role of Rural Development Schemes towards sustainable development

For the progress and further development of rural areas, the central and state governments run several Rural Development and Flagship schemes every year. Out of the several centrally sponsored schemes implemented by Government of India, one scheme i.e. Border Area Development Programme (BADP) is dedicated to the development of border areas. (Aayog, N. I. T. I. (2015). The main goal is to provide the border regions with basic infrastructure, address their particular developmental requirements and welfare of the people living in these isolated and difficult-to-reach places because of their proximity to the international border. It is important to mention here that there are many other development schemes that reach all parts of the nation irrespective of their geographical location.

Each border district comprises of community development blocks (CD’s /Border blocks) which are the basic units of BADP funds allocation and utilization. The

BADP funds are allocated as per the distance of the village from the international border. First, it is only in the villages that are 'within 0-10 km' of the international boundary with preferential priority to villages closer to the border. In the next group of villages located between 0-15 and 0-20 kilometres away are chosen and tackled when the initial 0-10 km range communities have been fully covered with basic infrastructure. When creating the priority list, the first village or hamlet in a block may be considered to be "0" km away from the international border if it is located further away as per the Press Information Bureau Government of India, Ministry of Home Affairs (pib.gov.in, 2015). The states receive funds based on three different criteria’s that are equally weighted; the international boundary length, population and the area of border blocks as per the new guidelines issued by Ministry of Home Affairs (Guidelines, 2020).

To further make villages smart, environment and sanitation becomes an important area of focus. Clean India Mission, or Swachh Bharat Mission (SBM), is another flagship programme that the Government of India has initiated to end open defection and enhance solid waste management. The Ministry of Jal Shakti, GoI, is the nodal Ministry for SBM-G. This Mission began in two parts, phase 1 lasting till October 2019 and Phase 2 is being implemented from 2020–2021 through 2024–2025 to help strengthen the efforts accomplished in Phase 1.

The goals of first phase were the elimination of manual scavenging, altering behaviour with regard to sanitary practises, and raising local awareness. The second phase aims to promote and make rural areas open defecation free. The mission is intended to achieve Target 6.2 of the sixth Sustainable Development Goal (United Nations 2015).

Swachh Bharat Mission-Gramin (SBM-G), a part of the above initiative, serves rural areas. Its objectives include achieving complete sanitation coverage in rural regions with an emphasis on secure sanitation. The mission aspires towards raising the general level of living in rural areas. The aim is to make rural areas clean and sanitised by implementing initiatives towards solid and liquid waste management in Gram Panchayats, to make them Open Defecation Free (ODF).

Several other schemes like Jal Shakti Abhiyan, NREGA (National Rural Employment Guaranteed Act), etc. work well in all villages of the country irrespective of their location.

1.3 Water & Environment Smart and Rural Sustainability

A village not only needs smart infrastructure but has to be smart in energy, agriculture, education, health and environment. Amongst various structural and functional components, soil and water form an integral part of environment that supports life, especially in rural areas where economy is majorly agrarian. Many folds rise in population has led to demand for food, which unintentionally resulted in the widespread application of agrochemicals, such as chemical fertilisers, pesticides, fungicides and weedicides, in agriculture fields. And the farmers are unaware of the repercussions and health hazards of prevalent use of these chemicals. Unquestionably, the basic soil structure as a consequence of the Green Revolution and the use of sophisticated agricultural equipment has changed. All such anthropogenic factors not only become the cause of heavy metal contamination in soil and water but has influenced the environment. Hence it is essential to check the quality of soil, water & its impact on environment.

1.3.1 Soil Quality

Due to its tremendous diversity and heterogeneity in nature, soil exhibits alterations at both the spatial and temporal levels (Kavianpoor *et al.,* 2012; Bhatti *et al.,* 2017). Furthermore, it contains many minerals, including heavy metals, as well as animals, plants, microbes and insects (Paul *et al.,* 2015; Tian *et al.,* 2017; Sharma, S. *et al.,* 2019), thus acting as a constant source of nutrients to the plants.

As reported in some studies, contamination of soil by heavy metals has altered the soil structure and composition thus degrading its quality and fertility (Martin, *et al.,* 2013; Bhatti, *et al.,* 2016; Kumar, *et al.,* 2016). Contribution of heavy metals like Arsenic, chromium, lead, cadmium, copper etc.in soil is through the application of chemical fertilisers & pesticides (Mortvedt, 1996; Milinovic *et al.,* 2008; Savci, 2012; Bhatti *et al.,* 2016b) as well as through geogenic contaminants. Presence of arsenic was reported in the drinking water samples in Bangladesh which was above the WHO guideline limits (Chakraborti *et al.,* 2010). Arsenic, cadmium, mercury and lead have been put in the list of harmful substances by Environment Protection Agency (EPA) of America (Khalid *et al.,* 2017., Rai, P.K., 2018). Similarly, Arsenic and cadmium are now in the list of important human carcinogens (IARC 2016). The impact of heavy metals like cadmium, arsenic and lead have been found in many research studies (Su *et al.,* 2014; ATSRD, 2015)

1.3.2 Water Quality

Water is the part of bio-chemical and physiological processes of all living organisms. As per multiple studies (Zhang *et al.,* 2010; Gorde and Jadhav, 2013; Halim *et al.,* 2018), nutrients, dissolved gases, micro-organisms and contaminants such heavy metals at incredibly low quantities are present in fresh water.

Exploitation and depletion of groundwater has become an environmental issue of concern in India particularly in agricultural states like Haryana and Punjab (Tripathi *et al.,* 2016). The agrarian state of Punjab has approximately 83% of its land under cultivation and utilises groundwater for potable and irrigation purposes. The proportion of gross irrigated area to gross cultivated area in Punjab is 98% as compared to the national ratio of 48%. (Kularni and Shah, 2013). Increase in irrigated area means increase in food production but at the stake of environment leading to issues like salinization and water logging, contamination of groundwater with heavy metals like arsenic and uranium especially in south-western districts of the state. (Tripathi *et al.,* 2016).

Over use of fertilisers, insecticides, and pesticides to enhance food production has polluted groundwater rendering it unsuitable for drinking or irrigation purpose. (Oberoi *et al.,* 2016). Pesticide poisoning not only causes death but also leads to reproductive abnormalities, neurological & behavioural disorders, premature hair greying and prevalence in cancer has been reported in the Malwa region of the state (Mittal *et al.,* 2014). Groundwater contamination with Uranium has been reported in Bathinda, Faridkot, Ferozepur, Ludhiana, Mansa, Moga, Muktsar (Planning commission, Govt. of India, 2013; Bajwa *et al.,* 2015; Virk, H.S., 2017, 2019a, 2020). Moderate to high concentration of Arsenic, Fluoride, Selenium have been reported in water samples from Bathinda, Muktsar (Kumar *et al.,* 2007; CGWB 2021). Birth abnormalities have been linked to the presence of arsenic in drinking water (Brender *et al.,* 2016).

1.3.3 Environmental Consciousness and Socioeconomic status

A survey-based investigation was carried out in the rural area of Hebei province in China to evaluate the causes of low level of awareness of environment amongst the farmers and poor environment of the province (Nan *et al.,* 2011). In another study, the awareness of farmers regarding the appropriate use and application of pesticides, the effect of pesticide residue on agricultural safety as well as their health consequences was examined (Hou and Wo, 2010).

Waste from homes and industries, agricultural runoffs, and the leaching of heavy metals via soil into groundwater are also responsible for heavy metal contamination (Mulligan *et al.*, 2011). Drinking and cultivating crops fed on contaminated water pose as a potential health hazard (Sharma, D., *et al.*, 2017). Physico-chemical properties provide an insight on the quality of groundwater, but they are subject to change due seasonal and geological fluctuations, pollution, and over- exploitation (Loni and Raut, 2012; Ashiyani *et al.*, 2015) of the resources.

Arsenic, Cadmium, and Lead are the metalloids and heavy metals that have either no known biological involvement in living systems or it is very minor (Duruibe *et al.*, 2007; Haloi and Sarma, 2012). All these contaminants, however, have negative effects when present in quantities that exceed the set safety limits. Prolonged exposure to such contaminants led to accumulation in the body resulting in a number of anomalies or irregularities in the healthy body.

1.4 Need and importance of the present study

People in villages by and large are not aware of issues related to health & hygiene, soil & water quality, waste management & disposal, environmental consciousness & awareness of the use/overuse and hazardous nature of fertilisers, pesticides etc. Contaminants through numerous human activities act as main contributor towards altering the physico-chemical characteristics of soil & water. Heavy metals and metalloids have witnessed an increase in the soil and water due to industrialization, urbanisation, and rurbanization of cities, towns, and villages. Despite being necessary for the growth and development of living things, heavy metals including chromium, cobalt, copper, iron, manganese, and zinc are persistent and dangerous even in very small amounts (Kar *et al.*, 2008; Reza and Singh, 2010; Assubaie, 2011; Faisal *et al.*, 2014). So, the groundwater, the only source of potable water, it is of great harm to human well-being with pollutants like heavy metals and metalloids (Merchant, 1994).

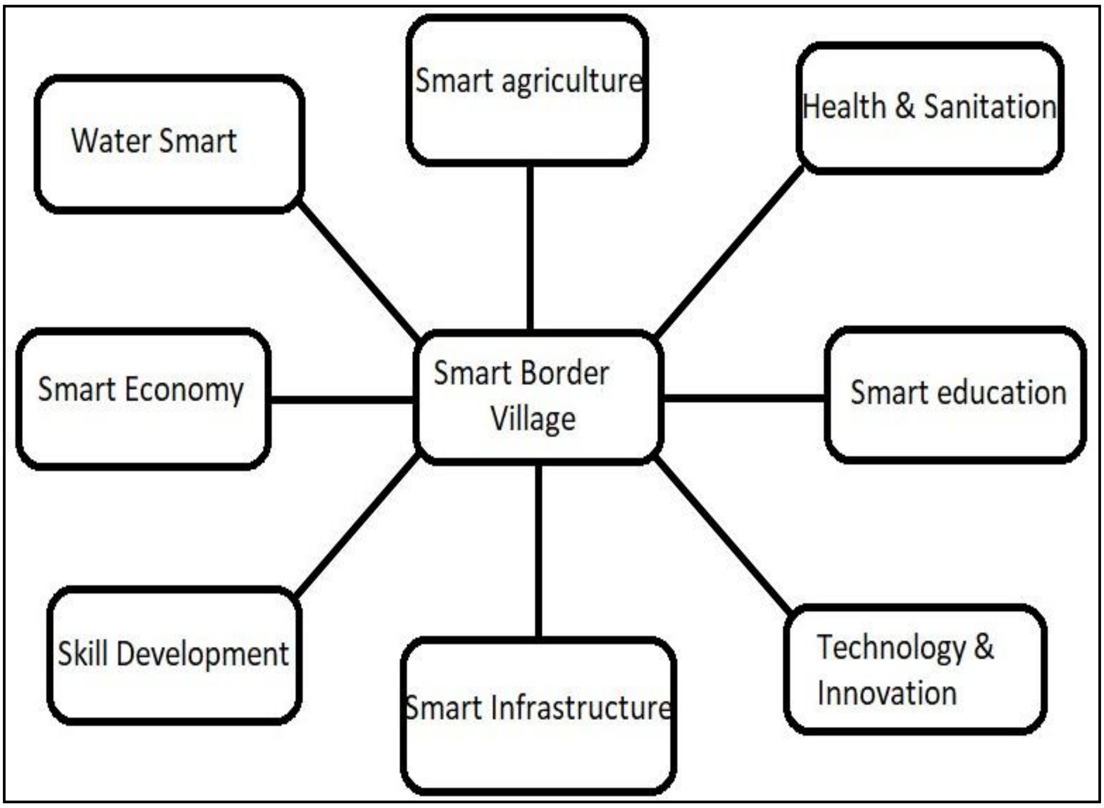
Several studies have been conducted on the assessment of soil and water quality in different areas across the globe as well in India. Research has been carried out to evaluate rural development in terms of the availability of basic amenities in villages, both at national and international level. Various village-based reports are available but work related to villages in the vicinity of international border, especially of the Punjab state have not been reported. There are various components of environment comprising of political, economic, social/cultural, legal, technological and environmental. The socioeconomic environment refers to a wide range of diverse aspects related to social and economic factors. Social aspects include demographics (population growth, structure etc.), lifestyle, social & cultural attitudes and values, behavioural pattern and social set up of the society like housing, community services pertaining to sanitation, health, solid waste disposal etc. Similarly, economic aspects like income, debt, credit source, levels of employment and unemployment etc. and environmental factors include activities that have a detrimental effect on environment like global warming, emission of greenhouse gases, pollution of natural resources that deteriorate the quality of air, soil and water, depletion and contamination of ground water, bioaccumulation of agro-chemicals etc. It has been found that soil and water quality has been fast degrading and declining thus posing a serious threat to rural areas affecting the economy and well-being of rural dwellers.

The present study focuses on the six border districts of Punjab namely Fazilka, Ferozepur, Amritsar, Gurdaspur, Tarn Taran & Pathankot. It is an effort to peruse the role of some Flagship schemes of the Indian Government towards the socio-economic growth and environmental appraisal of this Border zone. It as well is an attempt to get an insight into the multiple issues and challenges of these villages, environment in particular and bring best possible suggestions to make them Smart Border villages (Fig1.1) especially Water and Environment Smart.

1.5 Objectives of the study

Keeping in mind the smart village concept, the perusal of this work is done with the aim stated below:

- Monitoring of various environmental and socio-economic issues
- Assessment and monitoring of soil and water quality and heavy metal analysis.
- Analysis of Local problems of the villages under study.
- Evaluation of villages based on development and under various development schemes.



Source: Ray and Ali., 2021 (Modified)

Fig. 1.1: A Smart Border Village

CHAPTER 2

REVIEW OF LITERATURE

The review of literature outlines enough scope for conducting an in-depth analysis of the environmental appraisal of the border area villages of Punjab and the evaluation of some rural /border area development schemes as an effort to gauge the sustainable and Smart Village Concept paradigm. There have been very few studies undertaken on this subject earlier. The major limitations of the previous works have been the lack of an integrated approach towards a comprehensive study of the border villages and lack of tangible data in this regard. The present work is a modest attempt to bridge the gap. The major relevant studies have been reviewed as follows:

2.1 Smart Village Concept

Sustainable development being the prime need of the hour is fundamental across the social, economic and governance dimensions of a nation. For progress and good economic growth, a society needs to adopt sustainable ways to utilize & conserve the natural resources and embrace the environment (Ranade *et al.,* 2015; Shukla, 2016; Patel *et al.,* 2017; Gangani *et al.,* 2018). About 68.84% of the Indian population resides in villages where agriculture is the major occupation. A village thus is the fundamental unit of development, major source of employment and economy generation (Ramachandra, T.V., *et al*., 2015; Shukla, 2016; Gangani, 2018). Thus, for the progress of a nation, it is important to develop villages and make them smart. A Smart Village has accessibility & availability to basic amenities and infrastructure, better literacy rate, reduction in poverty, better health and education facilities, preferential use of renewable sources of energy etc. (Ranade *et al.,* 2015; Ramachandra, T.V., *et al.,* 2015 and Kochare *et al.,* 2019). A smart village is thus a self-sustaining entity with good governance and sustainability reflecting in all major aspects of development. Even Information & Technology (Shukla, 2016) can play vital role to enhance sustainable agricultural practices, automatic linking of procurement and distribution of farm produce, precision farming etc. to make villages smarter.

The Sansad Adarsh Gramme Yojana (SAGY) is a rural development programme that the Prime Minister of India introduced on October 11, 2014. The goal is to create model villages, or Adarsh Grammes, by enhancing better implementation of existing rural development initiatives and programmes. As part of this initiative, each member of parliament must adopt one village from their respective constituency, except their own or their home village and bring improvements to change it into a smart and sustainable village.

2.1.1 Socio-economic issues and environmental attitudes

Socio-economic assessment of a village or entity becomes an important tool to learn about the existing conditions of stakeholders or communities. This entails providing a baseline study with an insight into the current situation of the study area. This will help determine the issues that need the most concern**.** Moreover, it helps to analyse the impacts of the prevailing environmental conditions on the socioeconomic structure of an area and thus help to develop a set of guidelines for establishing sustainable communities.

A study conducted in China revealed that households with high income and high level of education show positive environmental concern. Considering age, people with older age are more concerned about environment than the people in younger age group. It was also found that socio-demographic characters like household size and employment status did not show any relation to environmental concern (Shen, J and Sajio, T., 2008).

In another study, a comparative analysis of thirty-three countries was conducted to measure the environmental attitudes or concerns. A close correlation between the economy of a nation and environmental concern was found. It was also seen that countries with improved economic conditions showed higher levels of environmental consciousness (Franzen, A and V. Dominikus, 2013).

The foremost problem in all the developing countries is the socioeconomic status. The regular implementation of numerous programmes & policies has upgraded the socioeconomic situation in rural areas. However, the residents in rural areas could not show similar economic development across the region, due to the existence of different economic strata’s even in a tiny community (Islam, M., & Mustaquim, M. D., 2014).

In a study conducted on socioeconomic status as predicator of environmental concern in African and developing countries, a positive correlation was found between the Perceived Socio-Economic Status (PSES) and environmental concern. People who belong to working class or are in lower to upper middle class show more environmental concern over economic growth & job opportunities. They are ready to protect environment and sacrifice income (Sulemana, I., *et al.*, 2016).

In the Indian villages of Kotni, Raipur and Chhattisgarh, a socioeconomic survey was carried out. Information regarding occupations, household types, medical facilities, educational opportunities, access to drinking water, sanitation systems, household electronics, toilet usage, financial status was collected during the survey. It was found that there was inadequate provision of basic services (such as the sanitation system and the supply of drinking water) so the local administration and government should come forward to find suitable measures to solve the problems (P, Kumari, 2022). Proactive government policies that support livelihood possibilities and local economic restructuring are desperately needed. They also need to make it easier for circular labour movement to occur as long as these local economies are underdeveloped (Chothani, C., *et al.,* 2021).

A comparative study was conducted in Latu District of Maharashtra to evaluate the socioeconomic status of farmers in an adopted and a non-adopted village. Variables like demography, income, expenditure, living standard, etc. were studied. It was found that majority of the people were mainly of middle age with large family size, medium income and medium size of land holdings. The respondents in both types of villages had medium level of socioeconomic status (Masudkar, D.D., *et al.,* 2017).

2.1.2 Environmental awareness amongst villagers

A correlation between environmental awareness and the socioeconomic set up of the rural population was found in the Turkish province of Afyonkarahisar and 14 villages in the Eskisehir region. Interviews/interactions, surveys, and questionnaires were used to determine the level of awareness of the villagers. The prudent use of agrochemicals and participation in environmental projects were considered indicators of the attitude and behaviour of people towards the environment. Low income, environmental awareness, and a lack of strict implementation of pollution control regulations on commercial and industrial units. Environmental awareness, choice & amount of fertiliser, education, selection of the type and quantity of agrochemicals did not have a statistical significance. Personal experience, the cost of the fertiliser/ agrochemical, or the advice of the salespeople or extension workers were also some other deciding factors. (Akca *et al.,* 2007)

A similar study was conducted in China to examine the knowledge of farmers in pesticide application and use safety as well as the impact of pesticide residue on agricultural safety and effects on health. With the help of questionnaires, data was obtained, and the findings showed that low level of awareness of farmers. The lack of understanding is caused by a number of factors, including education, gender, and whether the crop is being grown for commercial or personal consumption. Emphasis should be laid on enhancing farmers knowledge on the proper and safe utilization of pesticides by holding regular field training sessions and workshops (Hou and Wu, 2010).

To identify the factors contributing to poor environmental conditions in the province of Hebei and low environmental consciousness among farmers, a survey-based study was conducted. Three different stakeholder groups were involved: the farmers, the department of the environment, and business & institutional factors. It was discovered that farmers understand the value of environmental preservation but are hesitant to spend money on manure cleaning, reusing straw, etc. owing to a feeling of financial hardship. Irrespective of the age or level of education, just 7.56 percent of residents were aware of the numerous environmental problems. More efforts should be done by the government agencies and play a more active role to promote environmental protection. And there is need of centralised waste management system and public restrooms (Nan *et al.*,2011).

In a similar study conducted, the knowledge of environmental pollution and degradation among males, females, school students residing in the villages of Char Aicha and West Karnakathi located within the Barisal district, Bangladesh were primarily done. The study found that while people learn about the fundamentals of environmental pollution and degradation from media, they fail to integrate this knowledge into their daily routines especially the women. Due to ignorance, women did not handle home garbage properly and it was common to observe it lying in open spaces, particularly the ponds. Outcomes of the programme meant for raising awareness showed that, notably among primary school-aged children, approximately 90% of people adhere to the suggested practises. The study will offer background data for controlling degradation and pollution in the area (Uddin,2019).

Burning and disposing of household waste in open areas or backyards is a widespread practice in the communities, as reported in a study on environmental awareness in rural areas in Romania. The absence of a suitable waste disposal system of the municipal was the basic cause. It is not only a source of land and soil problems but the emissions of fumes and smoke contribute to environmental pollution thus impacting health and hygiene. This traditional method causes incomplete trash burning, which produces harmful gases like $PM_{2.5}$, PM_{10}, benzene, SO_2, and other pollutants. But air pollution and waste management are poorly understood in rural areas simply because of lack of awareness (Mihai *et al.,* 2019).

A study conducted in Ghana focused on the utilization of agrochemicals and their influence on maize production within the Ejura-Sekyedumase Municipality in the Ashanti Region. The respondents displayed a moderate level of awareness regarding the potential health repercussions associated with pesticide usage. Factors like education level, the number of school-going children, ownership of a TV or radio, prior experience with agrochemicals, and farm size were found to significantly contribute to understanding the health effects of pesticide application. This underscores the importance of increasing awareness among farmers about the health impacts of agrochemical use. It was recommended to maximise the use of interactive radio and field training sessions, and supplementing the safe agrochemical practises into the teaching curriculum (Mabe *et al.,* 2017).

2.1.3 Impact of Rural Development Programmes & Schemes

In pursuit of better livelihood people from rural areas migrate to nearby towns and cities. If better job prospects are created in rural areas, rural-urban migration can be reduced. There is a need of rural transformation that is both environmentally sound and socially inclusive.

The basic aim of rural development is to enhance the well-being and self-awareness of rural residents. For the growth of economy in a fast and sustainable way, rural development is a crucial component towards the prosperity of a nation (Rao, Srinivasa, P., 2019).

The Central and State Government of India has introduced numerous programmes to promote rural development. Some of the studies done in this context have been discussed. (Singhal, N. and Singh, Y., 2016) have investigated a number of programmes that promote sustainable rural development which were launched by the Indian government at regular intervals. It has been observed that sectors like basic infrastructure, agriculture, education and role of technology are some of the sectors which need special attention. National Institute of Rural Development, Hyderabad in 2018 provided a platform for the analysis & policy framework under the umbrella-Shyam Prasad Mukherji Rurban Mission (SPMRM). The objective was to make the villages smart and sustainable. A village needs to be smart in energy, agriculture, education, health, environment and possess smart infrastructure. A behavioural change in the village masses is a must to make villages achieve the Sustainable Development Goals (SDGs) in a smart and better way.

A thorough analysis of the numerous national and international initiatives done under the Smart Village concept for improvement of rural communities has revealed that the distinctness between the accessibility (developed) and non-accessibility (under-developed) of fundamental frame work is what makes a village developed, self-reliant, and an integrated unit. Due to the non-uniformity of rural areas and the significance of the digital transformation, it has also been discovered that smart development requires a place-based approach (Zavratnik *et al.*, 2018).

(Varma *et al.*, 2022) reported that infrastructural development plays basic or fundamental role in the upliftment of villages. It has a direct impact on the sustainable economic growth. Rather every sector of the society develops and progresses with advancement in the infrastructure.

To achieve goals of sustainable development, it is important to work on rural development. During Covid 19 many daily wagers had to travel back to their villages. This could have been avoided if greater employment prospects are created/available in rural areas, thus lessen the rural-urban migration. Today the rural areas need a makeover that is both environmentally sound and socially inclusive (Ray. A. & Ali. A., 2021). A few of the national level rural development programmes/schemes (Aayushi Namdev, 2018) have been mentioned in the Table 2.1 below:

Table 2.1: Rural Development Initiatives by the Indian Government

Schemes	**Launched in the Year**	**Objectives**
National Social Assistance Programme	1995	Financial assistance to widows and elderly
Member of Parliament Local Development Scheme (MPLADS)	1993	Development work in their respective constituency
Antodaya Anna Yojana (AAY)	2000	Food grains to BPL families

Schemes	Launched in the Year	Objectives
Sarv Shiksha Abhiyan	2000	Free education to children below 14 years
Sampoorna Grameen Rozgar Yojana	2001	Employment to poor and food
Provision of Urban Amenities in Rural Areas (PURA)	2004	Urban amenities to rural people
National Rural Employment Guarantee (NREGA)	2005	100 days of employment to unskilled labour
Swarnjayanti Gram Swarozgar Yojana (SGSY)/National Rural Livelihood Mission	2011	Women self- employment
Unnat Bharat Abhiyan	2014	Higher education to rural people
Sansad Adrash Gram Yojana (SAGY)	2014	Self- reliant villages
Swachha Bharat Abhiyan	2014	Sanitation and cleanliness
Pradhan Mantri Gram Sadak Yojana (PMGSY)	2015	Road connectivity
Prime Minister Rural Development Fellows Scheme	2018	Rural development
Jal Shakti Abhiyan	2019	Water conservation
Swachh Bharat Mission-Gramin	2019	Rural sanitation, ODF

Source: Literature survey

2.1.3.1 Border Area Development Programme (BADP)

This programme caters only the border areas of the country and is effective in seventeen states of India which share the international border. A central government sponsored scheme, the funds are specially for the inhabitants of the border states of India for the enhancement of their growth and development.

Although funding under the BADP has increased over the years, it is believed that the current amount is insufficient to significantly alter the state of infrastructure development and livelihood patterns in the remote and inaccessible border districts of Mizoram state. Being a tribal state, the Indian government should make an effort to examine the inappropriate increases in BADP fund allocation from a strategic point of view in order to ensure balanced development regardless to the location of the area (Lalthanmavii, 2019).

A study on BADP programme in Rajasthan state indicated that the residents of the border regions of the state were dissatisfied with the BADP work. In comparison to other states, Rajasthan has lower levels of female engagement in the planning and execution process. The amount of money used from 2010 to 2015 showed little variation from 40.75% to 61.41%. There have been instances when Government of Rajasthan delayed the transfer of central funds to the implementing organisations, cash being diverted while reflecting lack of coordination of the Border Area Development Programme with State and Central initiatives (Vaishnava, P. and Kannan, M., 2018) was observed.

Funds from the BADP are intended to fill in significant gaps and take care of its inhabitants urgent needs. Government directions state that a decentralised and participatory approach to its execution should involve the Panchayati Raj institutions, autonomous councils, other local authorities, and councils. In accordance with the rules, the state government may select or establish a nodal department to oversee the Border Area Development Programme (BADP) using the existing administrative structure. The nodal department in charge of the BADP in the state will meet one-on-one with line departments of the states, including power, rural development, electricity, roads & buildings, water supply, social welfare, and public distribution, to make sure the corresponding state/central schemes are implemented in the recognised border blocks (Dept. of Planning, Government of Punjab, 2011). Contrary to this it has been found during the present study that normally one meeting in a year is convened at the state level and that too for the finalization of the proposals of development works to be undertaken during next or current financial year. https://pbplanning.punjab.gov.in/border-area-development-programmebadp

2.1.3.2 Swachh Bharat Mission-Gramin (SBM-G)

It is a part of the national Flagship scheme Swachh Bharat Mission and is an initiative that serves rural areas. The objectives of this mission are to achieve complete and secure sanitation coverage in rural regions. The mission works towards improving the cleanliness levels and living standards of the villages by making them Open Defection Free (ODF) and clean through initiatives for solid and liquid waste handling.

The Swachh Bharat Mission (Gramin) has been quite successful in delivering universal sanitation coverage by providing individual family latrines, however many people still practise open defecation in rural India. Moreover, it was found that the solid and liquid waste management, a crucial component of Swachh Bharat Mission (Gramin), had not received much attention till date (Kumar, A., 2022).

In order to evaluate the influence of socioeconomic variables and regional difference on the implementation of the scheme, a survey-based Swachh sarvekshan data and cleanliness scores were regressed on a set of independent variables, which included the number of people living in poverty, net state domestic product (NSDP), state funding for health initiatives, literacy rates etc. The findings showed that the outreach of SBM scheme was impacted not just by the sub-national economy but also by the geographical location and literacy rate (Bhattacharya, S. *et al.*, 2018).

2.2 Soil Analysis

2.2.1 Heavy metals in soil

(Bhatti *et al.*, 2016 b) conducted research on the heavy metal content in soil and fodder (berseem) in the state of Punjab. The sampling sites were located near Beas and Sutlej River banks. The results showed that the contents of Cu, Pb, Co, Cd were well within the limits but for fodder crops, Cr content in Berseem plant was found above the permissible limit.

For heavy metal estimation in the agricultural soils of District Sangrur in Punjab, soil samples were collected from 50 distinct villages and flame atomic absorption spectrophotometry was done to analyse the heavy metals. It was found that the concentrations of all tested heavy metals, including Fe, Cr, Cu, Ni, Zn, Pb, Co and Cd were within the permissible limits established by Indian standards (Sharma and Chahal, 2018)

For the distribution & migration of heavy metals in the soil and groundwater samples in Peenya Industrial Area, Bangalore, Karnataka (India), forty-two groundwater samples and twenty-four soil samples were collected for investigation. 68% of the water samples exceeded the permissible limit. 45% of the samples had Cr, 40%, had Cd, 38% Pb and 28% had Ni exceeding the permissible limits. Over all 45% of the ground water samples failed to qualify the water quality index hence unfit for drinking. The concentration of Cr was very high in three of the soil samples (Ramakrishnaiah and Manasa, 2016).

(Bhatti *et al.*, 2016 a) conducted a study on the crops of sugarcane, sorghum and soils of Punjab to analyse the physicochemical parameters and heavy metal contents. These soils were under the cultivation of fodder plants, sugar cane and paddy. The soil samples were sandy in texture, low in organic matter and slightly acidic in nature. The heavy metal content of Cr, Co, Cd, Co and Pb were well within the limits but in sugar cane and sorghum crops the contents of Cd, Pb and Cr were above the limits. Bioaccumulation factor (BAF) was < 1 for Pb in Sorghum and >1 for Cu in Sugarcane.

One hundred and twenty samples of roadside agriculture soils from different sites of District Jalandhar, Punjab, India were subjected to certain physicochemical attributes as well as heavy metal analysis. The detected values of Cr, Pb, Co and Cu were within the limits. The results of potential ecological risk index, degree of contamination, contamination factor and Geo accumulation index clearly show that these soils had low contamination and low ecological risk of heavy metals. The northern region of the study area is more polluted as evident from spatial distribution maps (Dogra *et al.*, 2020).

In an international study carried out on heavy metal contamination in the soils worldwide clearly shows the mean content of heavy metals Cr, Cd, Pb, Zn, Ni, Cd, Hg and As (66.08, 49.60.1733.94, 289.78, 29.14 and 1.52 mg/kg, respectively) in city soils is more than that in the soils from fields 46.69, 38.03, 51.19, 117.35, 26.12, 1.50, 0.28, 21.19 mg/kg, respectively (Su *et al.*, 2014).

In a regional analysis, it was observed that the arsenic content in soil samples in Goniana region were significantly higher (with a mean of 9.58 mg/kg) than Talwandi Sabo block (with a mean of 3.38 mg/Kg) of Punjab. The presence of manganese and iron played a pivotal role in retaining arsenic within the soil. Organic matter and the amount of accessible and total phosphorus in the system affected its mobility. The increased arsenic contents in groundwater were mostly caused by the poor adsorption capabilities of the soils. Interestingly, there was a significant correlation observed between the adsorbed As (III) and the monitored arsenic levels, indicating that As (III) is mostly prevalent in the soil environment nearby. (Kumar, R., *et al.*, 2016).

Heavy metals were analysed by Inductively Coupled Plasma-Atomic Emission Spectrometer (ICP-AES) in the soils of 20 villages of District Fazilka, Punjab (India). The analysis revealed that the values of all heavy metals Ni, Cd, As, Pb, Cd, Zn were well within the limits of 20 mg/kg as given by ICRCL (Narang *et al.,* 2017).

The possible and potential health risks of the commonly present heavy metals are enlisted in Table 2.2:

Table 2.2: Heavy metals and their potential Health Risks

S. No.	Metal	Health Risk
1	Arsenic	Malignancies of the lungs, bladder, liver, skin, and kidneys. Toxic effects include impact on human reproduction, cardiovascular, hepatic, haematological, neurological, respiratory, and diabetic systems.
2	Cadmium	Diarrhoea, reproductive issues, gastrointestinal disorders, muscle and joint pain, lung damage, nephron and immunotoxicity, renal osteo-Malacia, tumours and cancer
3	Chromium	Cancer, allergic reactions, renal, liver, reproductive, and respiratory system harm, and skin conditions
4	Iron	Ailments such as cancer, diabetes, liver, heart, and neurodegenerative disorders
5	Mercury	Causes hearing, speech, mobility, and vision impairment and mental disturbance
6	Lead	Lead poisoning harms the nervous, skeletal, muscular, reproductive, immune and renal systems of living organisms.
7	Selenium	Abdominal pain, diarrhoea, numbness in limbs, nausea, irregular menstrual bleeding, , blood pressure and hair loss
8	Uranium	Cancer, effect on kidneys. Health effects not much documented
9	Nickel	Allergy, effect on kidneys, effect on sperm production, lung fibrosis, lung & nasal cancer.

Source: Literature survey

In another study, thorough analysis of heavy metals in the soil samples of Peenya industrial area in Bengaluru, India was conducted. Soil samples from twenty different locations were collected before and after monsoon season. Most of the soil samples showed more heavy metals content in the post monsoon season due to percolation of metal ions. The SQI index was also calculated, higher the SQI better is the quality of the soil. Most of the soils of Peenya area had low soil quality index (SQI) hence poor quality of soil. The data was also represented in the form of Spatial distribution maps (Gupta, M, N., *et al.*, 2019).

(Keshavarzi and Kumar, 2019) collected 68 composites samples of agriculture soils which were analysed for physicochemical parameters and heavy metals like Fe, Zn, Mn, and Cu in north-eastern Iran. The estimation of heavy metals was less than the EPA guidelines of Iran indicating that these soils have less contamination and low ecological risk. The results of geo statistical analysis revealed more accumulation of Zn in central region as compared to Cu and Mn in the South and north eastern regions respectively. The data was also represented in the form of spatial distribution maps.

2.3 Water Analysis

Water is an important natural resource which is essential for various life processes. It is an integral part of all physiological and biochemical cycles in plants, animals and humans. The elixir of life is an important parameter of environmental assessment. However, over-exploitation has led to high levels of contamination and pollution. Heavy metal contamination of water resources through pesticides, industrialisation, urbanisation is on the rise (Hua *et al.*, 2016).

The water quality is an amalgamation of many physico chemical properties, like pH, total dissolved solids (TDS), electrical conductivity (EC), total alkalinity (TA), and the presence of calcium (Ca), magnesium (Mg), total hardness (TH), chlorides (Cl^-), fluorides (F^-), sulphates (SO_4^{2-}). Due to their non-biodegradable nature, heavy metals and metalloids are particularly harmful to living creatures, even at low concentration (Hua *et al.*, 2016). As major occupation in Punjab especially in villages is agriculture, which largely depends on water so it becomes necessary to check the above parameters for quality assurance.

2.3.1 Heavy metals and Drinking water

Samples of drinking water from different locations in District Patiala, Punjab, India were evaluated for heavy metals using AAS and Hydride generation system. Most of the samples showed elevated levels of Aluminium (Al) and Nickel (Ni) whereas Cadmium (Cd), Arsenic (As), Selenium (Se), Lead (Pb), were found to be below the permissible limits (WHO). But one sample showed level of cadmium (0.006mg/l) above the permissible limit (0.005mg/l) (Sekhon and Singh, 2013).

To check the quality of drinking water and presence of heavy metal, a study was carried out in Dewan Gorah, District Palandri, Pakistan. Atomic absorption spectroscopy was done to evaluate the concentration of As, Cr, Pb, Fe, Cu and Ni. At all the locations, content of Pb and Cr were above the WHO permissible limit and water samples showed contamination of different pathogenic bacteria when subjected to microbial tests (Jamil *et al.*, 2018).

The heavy metal contamination in different water sources such as, tap water, groundwater, surface water, etc., gathered from different water sources in a specific area in Nigeria included Cd, Ni, Zn, Cr, Cu, Hg, Fe, Pb, Mn, Co. When these values were compared against national and international standards like WHO (2008), USEPA, EPA, etc. the amounts were found higher than the maximum permissible and desired limits. Hence the water samples were unfit for human consumption and not to be consumed without its proper treatment (Mohod, C.V. and Dhote, J., 2013).

Potable water in Iran showed that in 54.17% of the samples had higher values of heavy metals than the WHO and Iranian standards. Chromium, Arsenic, Cadmium, Lead, Copper, Iron, and Manganese were found more than the permitted limits in 18.75%, 30%, 16.66%, 33.33%, 7.69%, and 25% of the samples respectively. Pollution in drinking water was due to human and environmental factors as the possible causes (Parsi, Mehr, *et al.,* 2020).

An investigation was conducted in District Neelam in Pakistan to gauge the quality of drinking water. Samples from sources like surface water bodies, taps and springs were collected to evaluate physical, microbiological parameters and heavy metals. The findings revealed that the total dissolved solids (TDS) and electrical conductivity (EC) were 912.10 mg/L and 974.60 µS/cm respectively. Among the sixty samples collected, 76% exhibited bacterial contamination. Additionally, nitrite, nitrate, and phosphate concentrations were measured at 9.8, 15.0, and 15.1 mg/L, respectively and above the permissible limits of World Health Organization (WHO) for water quality standards. Furthermore, heavy metal testing indicated that levels of chromium (Cr) and lead (Pb) were elevated at 0.06 mg/L and 0.04 mg/L, respectively, exceeding WHO guidelines, with lead being identified as a significant water pollutant (Hayder *et al.,* 2022).

2.3.2 Heavy metals in ground water

High levels of heavy metals i.e. Selenium (Se) and Arsenic (As) in the groundwater samples in Majha area of Punjab i.e. Amritsar, Gurdaspur and Tarn Taran districts have been reported. Out of the 32 villages in Tarn Taran district, 7 villages had values higher (0.076-0.059mg/l) than the acceptance level (0.01 mg/l). From the list of 17 villages where Se was detected in two villages and had abnormally high value (0.094mg/l). In district Amritsar three out the 10 villages had Se content higher (0.039mg/l) than the acceptance level. (Virk, 2018).

Deteriorating quality of ground water of Malwa region of Punjab was reported due to over use of pesticides. It has led to the abundance of cations and anions and occurrence of Iron and Arsenic. The mean value of As was 9.37 and 11.01µg/l and Iron content was 0.009-5.41 mg/l and 0.074-7.7 mg/l in summer and winter season respectively (Kaur, T. et al., 2016).

In another study, the heavy metals analysis in groundwater resources in Ludhiana near Buddha Nullah & Ghaggar Rivers in Patiala districts of Punjab had been done. Samples of groundwater and handpump water were taken and concentration of essential elements and heavy metals was determined by EDXRF spectrophotometry. Metal pollution load index (MPLI) of 9 metals i.e. Chromium (Cr), Manganese (Mn), Copper (Cu), Zinc (Zn), As, Cd, Mercury (Hg,), Uranium (U) and Antimony (Sb) were more at sites in Ludhiana than those in Patiala. But MPLI of Ni and Pb at one of the sites in Patiala was higher than at Ludhiana. The results were indicative that handpump water near Buddha nullah (Ludhiana) was highly polluted & was not safe for drinking due to higher content of heavy metals than the water samples of Patiala (Kaur *et al.,* 2014).

(Ramachander *et al.*, 2015) carried out a quantitative estimation of 6 heavy metals Pb, Cr, Cu, Cd, Zn, Fe in 4 different areas of Hyderabad city in Andhra Pradesh. 24 water samples from different borewells of each area were collected. The analysis showed that content of Cr, Cd and Pb were moderately above the limit in two samples whereas other heavy metals were well within the WHO limits.

In another study the evaluation of different heavy metals in 240 samples of groundwater collected from 8 districts of Malwa region of Punjab was done. Pb, As, Fe, Cd, Cr, Hg, Zn were analysed. Out of 240 samples 219 were safe for the permissible limits of lead followed by arsenic with 161 samples unsafe. 98 samples were unsafe for the presence of Iron which was beyond the permissible limit. 152 samples had more than the permissible limits of Cadmium levels and 128 samples failed to fall under the safe detection limits of chromium. For Mercury 223 samples had more than the permissible limits of the metal whereas for Zinc only 11 samples out of 240 had more than the permissible limits of the heavy metal (Sharma and Dutta, 2017).

A study was conducted to assess the quality of the water, with particular attention to heavy metal concentrations, physico-chemical analysis, and genotoxic consequences.

The Buddha Nullah, a tributary of the Sutlej that flows through Ludhiana, Punjab, India, was the subject of 10 distinct places for this inquiry. The following seven heavy elements were analysed: Ni, Cd, Co, Zn, Cu, Cr, and Pb. The findings showed that all samples had levels of Co and Pb above the permissible limits. The heavy metal pollution index for the water samples ranged from 271.75 to 10,306.36, surpassing the critical value of 100. This signifies a notable level of metal pollution in the water samples from Buddha Nullah (Kaur, J., *et al.,* 2021).

In a case study from India, heavy metals and mutagenic potential of pond water samples taken from 11 various locations from District Amritsar, Punjab was done. The water samples were collected for a period of two years for eight different seasons and heavy metal analysis was carried out using MPAES. The highest metal concentration was detected during the winter season followed by summer and monsoon season whereas lowest heavy metal concentration was seen during post monsoon season. Six out of the eleven sampling sites had Heavy Metal Pollution (HPI) index above the critical index of 100. The maximum mutagenic potential of water samples was observed during summer and winter season (Rajput *et al.*, 2020).

A number of studies pertaining to the presence of heavy metal in the soil & water samples are shown in Table 2.3 given below:

Table 2.3: Various studies done on Heavy Metal Analysis in water and soil samples

Study area	**Sample Type**	**Parameter studied**	**Results**	**References**
Patiala, Punjab, India	Water	Al, Ni, Cd, Pb, As, Se, Cr	Ni & Al (0.01 & 0.05 mg/l), above permissible limits, at one site Cd 0.006mg/l, above the limits	Sekhon and Singh, 2013
Ludhiana & Patiala	Water	Cr, Mn, Cu, Zn, As, Cd, Hg, U, Sb	The Metal Pollution Load Index (MPLI) of these heavy metals higher in Ludhiana MPLI of Nickle and Lead high in Patiala	Kaur, T., *et al.,* 2014
Andhra Pradesh	Water	Cr, Cd, Cu, Fe, Zn, Pb	Pb, Cr, Cd higher than the permissible limits in 2 samples	Ramachander, 2015
Malwa region	Water	Pb, As, Fe, Cd, Hg, Zn	Out of 240 samples 98,240,152, 128, 223, 11of the samples had these heavy metals above the permissible limits, respectively	Sharma & Dutta, 2017
Pakistan	Water	As, Cr, Cu, Fe, Pb, Ni	All within limits	Jamil, 2018

Study area	**Sample Type**	**Parameter studied**	**Results**	**References**
Amritsar District	Water	As, Se	0.059 As, 0.0039 Se	Virk, 2018
Pakistan	Water	As, Cr, Cu, Fe, Pb, Ni	All within limits	Jamil, 2018
Amritsar District	Water	As, Se	0.059 As, 0.0039 Se	Virk, 2018
Budhha Nullah, Ludhiana	Water	Ni, Cd, Co, Zn, Cu, Cr, Pb	Co, Pb more than the permissible limits, HPI 271.75-10.306.36 exceeding the limits	Kaur, J., *et al.,* 2021
Amritsar District	Water	As, Cd, Co, Cr, Ni, Pb, Se, Zn	6 out of 11 sites HPI> 100, the critical value index	Rajput, 2020
World over	Soil	Cr, Cd, Pb, Zn, Ni, Cd, As, Hg	66.08,49.60,1733.94,289.78,29.14,1.52mg/kg respectively	Su *et al.*, 2014
Near Beas Sutlej Banks	Soil & Fodder	Cu, Cd, Co, Pb	All within limits	Bhatti *et al.*, 2015
Punjab	Soil& Crops	Cu, Cr, Cd, Pb, Co	Cr, Cd, Pb higher in crops than soil samples	Bhatti *et al.*, 2015
Karnataka	Soil	Cr, Cd, Pb, Ni	Cr 45%, Ni 28%, Cd 40%, Pb 38%, Fe 28% respectively of the samples exceeded the permissible limit	Ramakrishniah & Manasa, 2016
Fazilka	Soil	Pb, Ni, As, Zn, Cd	All within permissible limits	Narang, 2017
Sangrur	Soil	Fe, Cu, Zn, Ni, Pb, Co, Cd, Cr	Cu, Pb, Cd and Cr above the limits while Fe, Co, Ni, Zn were above the limits	Chahal and Sharma, 2018
Jalandhar District	Soil	Cr, Cu, Co, Pb	All within the permissible limits	Dogra, N., *et al.,* 2019
Iran	Soil	Fe, Zn, Mn, and Cu	Majority of the heavy metals were below the permissible limits; Cu and Mn more in south and north eastern parts, Zn more in central part of the studied area.	Keshavarzi and Kumar, 2020

Study area	**Sample Type**	**Parameter studied**	**Results**	**References**
Karnataka	Soil	Pb, Cu, Fe, Cr, Cd, Zn, Ni, As in pre and post monsoon samples	Fe, Ni, Pb, Zn, Cr content more in post monsoon samples	Gupta, M, N., *et al.,* 2019

Source: Literature survey

2.4 Physcio-chemical parameters of soil

Soil is a fine powder formed from the weathering of rocks. It is composed of particles, minerals, air, water and organic matter. The composition of soil particles i.e. sand, silt and clay vary geographically. Soil thus possesses certain physical and chemical properties like pH, Electrical conductivity (EC), porosity, moisture content (MC), Bulk density (BD), soil organic matter (SOM), organic carbon (OC), and particle size etc. These physicochemical properties define several characteristics of the soils of an area.

(Sharma, B. & Bhattacharya, S., 2017) conducted a study on the soil samples of Pandoga sub watershed District Una, Himachal Pradesh, India. Nine surface soil samples from the watershed catchment area were taken and a relationship between bulk density and some physicochemical parameters like moisture content (MC), organic carbon (OC), soil organic matter (SOM) and available nutrient was studied. A strong negative relationship of bulk density with clay and a strong positive correlation of bulk density with available macronutrients was observed. Soils of all the sampling sites had bulk densities <1.5, indicating good soil conditions for the growth of plants. Sand content had higher effect on the soil bulk density than other soil properties. More over bulk density is independent of the acidic or alkaline nature of soil. A reverse correlation between bulk density and soil organic matter was observed. Macronutrients showed a noticeable positive correlation with bulk density. The management of the watershed displayed spatial effects on soil quality across various sampling sites, suggesting potential degradation of the soil quality in the future.

pH, OC, P, Ca, Mg and heavy metals like Cu, Cr, Pb, Co were analysed in the agricultural soil samples of District Jalandhar (Dogra, N. *et al.*,2019). All these parameters were well within the permissible limits.

The analysis of soil samples from some villages in Punjab revealed that soils are acidic, have sandy texture, and low organic matter content. The pH, EC, bulk density, water holding capacity were well within the range. Soil texture was sandy while Ca, Mg, Na, K, CO_3 were well within in the range (Bhatti *et al.,* 2016). Several studies have been done on the physico- chemical analysis of soils and some of them have been discussed and mentioned in Table 2.4 given below:

Table 2.4: Various studies done on Physico-chemical parameters in soil samples

Karnataka	pH, Acidity, EC, Cl^-, Fe, Cu, Ni, Pb, Zn, Cd, As, Cr, SQI	All except Acidity, Cl^-, Cd, Cr are high in post monsoon samples	Gupta, M, N., *et al.,* 2019
Sangrur, Punjab, India	pH, EC, Na, K, CEC, Ca, TOC	Na, K, CEC, were above the permissible limits	Sharma and Chahal., 2018
Punjab	pH, EC, Soil composition, SOM, Ca, Mg, Na, K, N, P, CaCO3,	EC 0.307-0.0.723mS/cm, sandy texture 3.15-5.33%, SOM 1.83-2.91%, CaCO3 high so calcareous soils, Ca, Mg abundant, Na, N, K in limits	Bhatti *et al.,* 2016b
Punjab	pH, EC, soil texture, SOM, OC, N, P, K	pH 6.421-6.65, EC-0.220-0.602 mS/cm, Soil texture 78-93.67%, SOM 2.73-4.17%, OC 0.10-0.35g/kg, N-0.033-0.084g/kg, K-1.118-1.436g/kg respectively.	Bhatti *et al.,* 2016a
Jalandhar District, Punjab	pH, OC, P, Ca, Mg	pH acidic to alkaline, OC 6.9%	Dogra *et al.,* 2019
Himachal Pradesh, India	Bulk density, Moisture content, pH, EC, OC, SOM,	Sand 75%, silt 23.33%, clay 15.66% B.D. 1.54gm/cm3, OC 1.42%	Sharma and Bhattacharya., 2017
Gonian Bathinda, Punjab	pH, EC, BD, TOC, SOM, TP	pH (7.92 – 9.61), EC (0.08 – 0.78 dS/cm), BD (0.986 – 1.296 g/cm3), TOC (0.12 – 1.08%), SOM (0.21 – 1.86%), TP (382.16 – 1609.19 mg/kg) and Avl. P (2.00 – 51.73 mg/kg).	Kumar, R., et al 2016
Talwandi Saboo, Bathinda, Punjab		pH (8.24 – 9.42), EC (0.18 - 0.99 dS/cm), BD (1.042 – 1.379 g/cm3), TOC (0.26 – 1.1%), SOM (0.45 – 1.89%), TP (230.81 – 922.70 mg/kg) and Avl. P (4.03 – 31.89 mg/kg)	

Source: Literature survey

2.4.1 Soil Texture/ Soil composition

Soil texture is an important physical parameter which influences many other parameters of soil. The research findings indicate that the farming soil in Bishoftu farm land in Ethiopia, is a combination of clay loam, sandy clay loam, and loam, with sand accounting for 47.33% of its composition, clay up to 25.67%, and silt comprising 27%. The maximum moisture content of soil was 27.02% and minimum was 21.46%. There is positive relationship between soil depth and parameters such as soil compaction, total organic carbon, total organic matter, and total nitrogen. Soil compaction is also positively linked to several other properties, including soil pH, electrical conductivity, sand content, cation exchange capacity, organic matter, and total nitrogen. Conversely, there is a negative correlation between soil compaction and the proportions of clay, silt, and total organic carbon ($p>0.05$) in soil samples (Woldeyohannis *et al.,* 2022).

Fifteen soil samples, collected from various locations within the Oni Gambari Forest Reserve in Nigeria, underwent a comprehensive analysis of their physicochemical characteristics (Opeyemi *et al.,* 2020). These characteristics encompassed soil texture (sand, silt, and clay), porosity, bulk density, pH levels, organic matter content, available phosphorus, total nitrogen, exchangeable bases (Ca, Na, K, and Mg), and available micronutrients (Mn, Zn, Fe and Cu). The results indicated that the soils predominantly exhibited a combination of loamy sand and sandy loam textures, with sand content ranging from 71.2% to 84.2%, silt content between 7.4% and 10.4%, and clay content from 6.4% to 19.4%. Porosity values ranged from 35.2% to 44.1%, while bulk densities were within the range of 1.61 to 1.83%. The organic matter content was moderately within the range of 1.68% to 2.60%, and the soil pH levels were slightly acidic to neutral, measuring between 5.90 and 6.60. These findings suggest satisfactory soil nutrient levels. Additionally, the soils exhibited elevated levels of available phosphorus (10.98 to 18.22 mg/kg) and total nitrogen (0.35% to 0.65%).

In a separate study conducted in Columbia (Marín-Pimentel *et al.,* 2023), surface soil samples were found to consist of 46% sand, 20% silt, and 41% clay in certain regions. Meanwhile, in the Damodar River basin (Hoque, M. M, *et al.,* 2023) surface soils exhibited sand content ranging from 39.78% to 79.46%, silt content between 6% and 40%, and clay content ranging from 13.38% to 22.56%. Subsurface soils in the same region showed sand content in the range of 35.60% to 81.36%, silt content between 5% and 48%, and clay content ranging from 11.43% to 20.50%).

The soil texture composition of saline and alkaline grassland soils of Kayseri, Turkey showed that sand, silt and clay varied from 17.2 - 93.4%, 3.15 - 67.0 % and 0.62 - 73.4%, respectively (Zeki, G., *et al.,* 2010).

2.5 Physicochemical parameters of water

Various studies have been carried out on the physico- chemical parameters of water which have been tabulated in Table 2.5 as shown below:

Table 2.5: Various studies on physico-chemical parameters of Water

Study area	Parameters	Results	Reference
Eight districts of Punjab	$Na^{+,}$ K^{+} Mg^{2+} Ca^{2+} F^{-} Cl^{-}, NO_3, SO_4, Hardness	The groundwater quality 6% of the study area is fit, 18% marginal and 76% is unfit for irrigation purpose.	Chopra and Krishna, 2014
Sukena village, Maharashtra, India	pH, TDS, alkalinity, BOD, DO, Hardness, F-, Cl- NO3-, Fe, Temp., Turbidity	TDS, DO, Alkalinity, BOD and hardness, above the limits.	Savale *et al.,* 2015
SW Punjab, India	Na+, Ca^{+}, Mg^{2+}, K^{+} and HCO_3^{-} , SO_4^{-}, Cl^{-}. F^{-} and As.	Na^{+} > Ca^{2+} > Mg^{2+} > K^{+} and HCO $^{3-}$ > SO_4^{-} > Cl^{-}. Fluoride content in 75 % of the samples above permissible limit. Mean value 9.37 (summer) 11.01µg/L (winter) respectively.	Kaur, T., *et al.,* 2017
Pakistan	pH, TDS, EC, Alkalinity, Cl^{-}, F^{-}, COD, Hardness	Na^{+} high in 8 out of 15 samples (21.4-37mg/l)	Jamil *et al.,* 2018
Malwa region, Punjab	pH, TA, TH, TDS, Na, K, Ca, Mg, SO $^{4-}$ NO^{3-} , Cl^{-}, Fe, Cd, As, Cr, Zn, Hg etc.	All parameters above permissible limits. Groundwater highly contaminated and not fit for human consumption and domestic applications	Sharma, R. 2018
Pakistan	pH, EC, Ca, Mg, TDS, taste, colour, odour	10/100 samples slightly yellow coloured and slight smell, 14 are brackish, TDS up to 5600mg/l, EC >800Ms/cm, Mg 2.6-162mg/l, Ca 36-324mg/l, hardness >1300mg/l	Arshad *et al.,* 2019
Bangladesh	pH, EC, TDS, TS, TSS, DO, Temp.	EC>300mg/l, TSS 200mg/l	Uddin and Rajonee, 2016
Ludhiana, Punjab	pH, TDS, TS, TSS, DO, BOD, EC, COD, Temp., Hardness, Ca, Mg, Cl-, PO^{4-}, NO^{3-}, Na, K	EC high, DO low, COD, BOD high upstream, TS 3720mg/l, TA 733.3-2100mg/l, NO_3^{-} 67.63-114.91mg/l, PO_4^{-} 7.68mg/l	Kaur *et al.,* 2020
Karnataka	pH, TDS, EC, Hardness, Ca, Mg, NO^{3-}, Cl-, Alkalinity	pH 6.1-8.3, TDS 640-3298mg/l, EC 1005-5497us/cm, Ca 38-277.5, Mg 13.2-143.2, Cl^{-} 35-661 mg/l, NO_3 $^{-}$ 2.90-368 mg/l, Alkalinity 86-506mg/l	Rama Krishnaiah., 2016
Karnataka	pH, TDS, EC, Cl, F, SO^{4-}, Alkalinity, Turbidity,	pH 7.01-7.50, EC 1-3.9Ms/cm, TDS 460-2070mg/L, TH 127.1-571mg/L, Cl^{-} 111.7-603 mg/L, F^{-} 0.5-1.6 mg/L	Hiremath *et al.,* 2012
Nagaland	pH, TDS, Alkalinity, Total hardness, Cl, DO, Mg and Ca hardness	pH 7.05- 7.34, Total alkalinity 55.6-65 mg/L, Chloride 14.1-16.3mg/L, DO 8.68- 9.56 mg/L, 4.89-7.18mg/L, TH 55 -62.3mg/L, Ca hardness 18.6-19.6 mg/L, Mg hardness 8.5-10.4 mg/L and TDS 111.7-137.1mg/L	W, Temjen and Singh, M.R., 2017

Source: Literature survey

Village Sukena in Nashik, Maharashtra (India) was evaluated for environmental cleanliness as well as basic amenities such as water availability, housing hygiene, solid and liquid waste management, and grey water management. Various parameters such as pollution level, organic matter, pesticide concentration, acidic nature, bulk density, porosity, and several physico-chemical factors like pH, total dissolved solids (TDS), biochemical oxygen demand (BOD), and total water hardness, were examined for quality assessment of soil and water. Notably, alkalinity, hardness, and TDS levels were elevated in samples both before and after monsoon. OC, Total Nitrogen, available P and K were found to be more than the permissible limits. (Savale *et al.*, 2015).

(Uddin, 2016) studied the environmental conditions of two villages neighbouring the University of Barisal. Water parameters such as pH, dissolved oxygen (DO), electrical conductivity (EC), total solids (TS), and total dissolved solids (TDS) were estimated. The soil exhibited low organic matter content and had a neutral to slightly alkaline pH. Unfortunately, the quality of water in the area was low. The EC and TSS were much beyond the permissible limit.

The analysis of physico chemical parameters of water was conducted in ten distinct locations along Buddha Nullah, which is a tributary of the river Sutlej, within the Ludhiana district of Punjab. EC, pH, TDS, Cl, NO_3, PO_4, Na, K along with heavy metals were measured in the water samples (Kaur, J. *et al.*, 2020).

As per a report on water logging in Punjab (Planning commission, Government of India, 2013), southern and south-west regions of the state have reported high levels of nitrate and fluoride. Districts like Bhatinda, Mansa, Muktsar, Faridkot, Ferozepur, Ludhiana, Hoshiarpur, Tarn Taran, Moga, Gurdaspur, and Amritsar have nitrate concentrations exceeding the critical level. Some parts of Amritsar, Bhatinda, Gurdaspur, Sangrur, Barnala, and Muktsar districts have fluoride content above 10 mg/l. The alkaline groundwater of Bathinda is moderately to severely saline, and has high fluoride concentration (Kaur, T. et al., 2016; CGWB, 2007). The WHO/BIS standards of various parameters of water are shown in Table 2.6 below:

Table 2.6: WHO/BIS standards of physico-chemical parameters of water

S. No.	Parameter	Acceptable Limit (mg/l or ppm)	Permissible limit (mg/l or ppm)
1	pH	6.5-8.5	No relaxation
2	TDS	500	2000
3	EC	200 us/cm	400 ug/cm
4	Chlorine	250	1000
5	Fluoride	1	1.5
6	Sulphate	200	400
7	Nitrate	45	No relaxation
8	Calcium	75	200
9	Magnesium	30	100
10	Alkalinity	200	600
11	Hardness	200	600
12	Iron	0.3	No relaxation

Source: WHO/BIS standards

2.6 Heavy metals in Soil and water samples of Punjab

While reviewing the literature a number of studies related to presence & estimation of heavy metals in ground and drinking water samples were taken up. This survey of literature also brought to light many issues that are related to the soil and water quality of the state that are affecting the human health, animals, crops as well as polluting the environment. Table 2.7 shown below highlights the major issues that have been reported in the soil and water samples of Punjab State.

Table 2.7: Major Issues reported in soil and water samples in Punjab State.

S. No.	Problem/Issue	District/Block
1	Overuse of pesticides	All districts
2	Brackish water	Gurdaspur, Tarn Taran, Faridkot, Patti, Bathinda, Nadala, Jhunir
3	Selenium in ground water	Nawanshahr, Sangrur, Hoshiarpur, Tarn Taran, Ludhiana, Ferozepur, Fatehgarh Sahib, Kapurthala, Jalandhar
4	Flooding	Ferozepur, Amritsar, Ludhiana, Patiala, Sangrur
5	Water Logging	Ferozepur, Fazilka, Muktsar
6	Salinization of ground water	Fazilka, Ferozepur, Bathinda, Mansa, Moga, Faridkot, Abohar, Muktsar
7	Industrial pollution in ground water	Ludhiana, Sangrur, Ropar, Jalandhar

Source: Modified (Kaur, G., 2022; Sharma, 2014)

The commonly occurring major contaminants like fluoride, chloride, nitrates, and salinity reported in water samples across Punjab are summarised in Table 2.8.

Table 2.8: District-Wise contaminants of water and the possible source

S. No.	Contaminant	District/Block	Possible source
1	Chloride (>1000mg/l)	Muktsar, Ferozepur	Chlorination of water
2	Fluoride (>1.5mg/l)	Amritsar, Fazilka, Ferozepur, Gurdaspur, Moga, Muktsar, Bathinda, Patiala, Faridkot, Sangrur, Mansa, Mohali, Fatehgarh sahib, Kapurthala	Weathering of rocks
3	Iron (>1.0mg/l)	Ferozepur, Gurdaspur, Bathinda, Faridkot, Hoshiarpur, Mansa, Sangrur, Ropar, Fatehgarh sahib	Weathering of iron containing rocks, corrosion of metallic pipes etc.
4	Nitrate (<45 mg/l)	Bathinda, Ferozepur, Faridkot, Fatehgarh Sahib, Gurdaspur, Hoshiarpur, Kapurthala, Jalandhar, Ludhiana, Muktsar, Moga, Mansa, Nawan Shaher, Patiala, Rupnagar, Sangrur	Agriculture runoff, waste water, animal feedlots, septic tanks or urban drainage etc.
5	Salinity (as EC in µS/cm)	Ferozepur, Faridkot, Bathinda, Mansa, Muktsar, Sangrur	Geological formations and long residence time

Source: Modified, (Kaur, G., 2022; CGWB, 2020-12., Sharma, 2014)

Similarly various studies carried out on heavy metals such as Arsenic, Uranium, Selenium, Chromium, Lead, Cadmium, Nickel, Manganese, Mercury detected in groundwater of Punjab have been enlisted below in Table 2.9.

Table 2.9: Summary of various studies on Heavy Metal reported in Ground water of Punjab State.

S. No.	Heavy Metal	District/Block	Range in ground water	References
1	Arsenic	Gurdaspur	4-42µg/l	Virk, H.S., 2020, Hundal *et al.*, 2007
2	Arsenic	Amritsar, Tarn Taran	10-43µg/l	Hundal *et al.*, 2007
3	Arsenic	Amritsar	3.80-19.1µg/l	Hundal *et al.*, 2008
4	Arsenic	Ferozepur	11-688µg/l	Hundal *et al.*, 2007
5	Arsenic	Ferozepur, Fazilka	1.0-59.6µg/l 5.015-10.990 mg/l	Bajwa *et al.*, 2015 Narang, *et al.*, 2018
6	Uranium	Bathinda, Mansa, Faridkot	2-644µg/l	Kumar *et al.*, 2015
7	Uranium	Ferozepur	2.8 – 579 µg/l 30-331.4 µg/l	Kumar *et al.*, 2015., Virk, H.S. 2020
8	Uranium	Fazilka, Tarn Taran	30-366µg/l	Virk, H.S. 2017, 2020,
9	Uranium	Ferozepur, Faridkot,	0.5 – 579 µg/l	Bajwa *et al.*, 2015

S. No.	Heavy Metal	District/Block	Range in ground water	References
10	Chromium	Mansa, Bathinda	< 0.5 – 228 µg/l	
11	Cobalt		<0.2- 481 µg/l	
12	Copper		<0.05- 15 µg/l	
13	Iron		10 – 3424 µg/l	
14	Lead		< 0.01 – 444 µg/l	
15	Manganese		< 0.5 – 508 µg/l	
16	Nickel		< 0.2 – 308 µg/l	
17	Zinc		< 0.05 – 2365 µg/l	
18	Iron	Amritsar, Tarn Taran	8.90-14.58 ppm	Virk, H.S., 2017, 2019
19	Selenium	Amritsar, Tarn Taran, Gurdaspur, Bathinda		Virk, H.S., 2017, 2019 (a), 2020, Singh, A., *et al.*, 2021
20	Chromium	Bathinda	>0.003µg/l	Singh, A., *et al.*, 2021
	Mercury	Bathinda	>1ppb	Singh, A., *et al.*, 2021

Source: Literature survey

The Press Information Bureau, Government of India, Ministry of Jal Shakti has brought some alarming results in a published report (pib., 2021) As part of quality monitoring of ground water, the Central Ground Water Board (CGWB, 2021) has reported that arsenic, lead, cadmium, chromium and uranium in many of the districts of Punjab have been found to be above the permissible limits of BIS. These reports have been mainly from the Malwa and Doaba regions of Punjab (Table 2.10).

Table 2.10: Number of Districts of Punjab with Heavy metals beyond permissible limits

S. No.	Heavy metal	Districts	No. of Habitations	Permissible limit
1	Arsenic	Mansa, Faridkot, Sangrur	10	0.01mg/l
2	Lead	Bathinda, Ferozepur, Muktsar	06	0.01mg/l
3	Cadmium	Fatehgarh Sahib, Ludhiana, Patiala, Sangrur	08	0.003mg/l
4	Chromium	Bathinda, Mansa, Sangrur	10	0.05mg/l
5	Uranium	Bathinda, Faridkot, Ludhiana, Ferozepur, Muktsar, Patiala, Sangrur, Fatehgarh Sahib	-	30µg/l
6	Iron	-	10	1.0mg/l
7	Fluoride	-	176	0.5–1.5mg/l

Source: pib, GOI, Ministry of Jal Shakti (2021)

In another report that was released in the press also reflected the seriousness about the grave situation of quality of underground water of Punjab, in a project sponsored by World Bank. A really troubling data came across with the reporting of large number of heavy metals in the underground water used for drinking purpose also. A survey of 1971 villages of the state was conducted by Punjab Water and Sanitation Department and randomly the samples were taken from different villages from the various districts of the state. As per the report heavy metals like Arsenic, Lead, Uranium, Fluoride, Aluminium, Selenium, Nickel, Mercury, Chromium were reported in the water samples. Many of the heavy metals like uranium, lead, mercury, selenium and aluminium were found above the permissible limits as per WHO/BIS standards. Water samples of all the villages showed the presence of the above stated heavy metals but well within the permissible limits. It was suggested by the Department of Water and Sanitation to install reverse osmosis (RO) systems in the villages where the parameters were above the permissible limits. Heavy metal contamination has been reported in these water samples. Table 2.11 given below shows the details of the report of underground water given by Punjab Water and Sanitation Department.

Table 2.11: Number of Habitations with heavy metals in potable water of Punjab

S.No.	District	No. of Villages	Heavy metals	Beyond permissible limit
1	Amritsar	82	-	Arsenic
2	Bathinda	22	Cr, As, Pb, Se,	Uranium, Mercury
3	Ferozepur	89	U, Pb, Al, Se	
4	Ludhiana	95	Al, Se, Hg	Lead
5	Gurdaspur	206	Cd, Ni, Al, As.	Lead
6	Tarn taran	48	U, As, Ni, Pb, Se	
7	Jalandhar	165		Lead, Selenium
8	Fazilka	22	U, F^- , Al	
9	Fategarh Sahab	51	U, F^- , Se, Ni	
10	Kapurthala	67	Se, Pb, Al	
11	Hoshiarpur	150	Cr, Pb, Se, Ni, Al, As.	
12	Moga	26	Al, Pb, U	
13	Pathankot	113	Al	
14	Patiala	41	-	Lead
15	Sangrur	62	U, Pb, Se, F^-	
16	Nawan Shahar	32	Hg, Se, Al, Pb	
17	Mohali	46	Al, Pb, F^-	
18	Ropar	290	Pb	Al

Source: Times of India, 2018

(Singh, K. *et al.*, 2021) carried survey on the water samples of Bathinda district for the presence of carcinogenic heavy metal like Mercury (Hg), Chromium (Cr), Arsenic (As), Cobalt (Co), Cadmium (Cd) and Selenium (Se) in the drinking water samples. The results showed that Cr and Hg were beyond the permissible limit in all the samples while 16% of the samples had Se beyond the permissible limit. All other heavy metals were present within the limits.

2.7 Research Gap

From the review of literature, it is evident that a number of studies related to aspects like environment, socioeconomic status, rural development, quality of soil and water etc. have been conducted in different parts of Punjab, but no such work with a holistic approach with special reference to the border districts/villages of Punjab has been done.

Hence the objective of this work is to investigate the impact of shared boundaries and common water bodies (rivers) of two nations on the life and livelihood of the local dwellers. The project has been taken up with the following research gaps:

a) The quality of soil and water in the border belt of Punjab has not been studied.

b) The effect of the proximity to the international border on the socioeconomic status of the people living in the zone of exclusion and inaccessibility has not been done.

c) Assessment of the villages on the basis of infrastructure & development has never been undertaken.

d) The challenges and problems which the villagers living in the border districts of Punjab face has not been studied.

CHAPTER 3

MATERIALS AND METHODS

Objective 1: Monitoring of various environmental and socio-economic issues

Under this objective the randomly selected villages under the study area of six border districts were surveyed. All the villages were visited and interviews, group discussions and questionnaire method (Annexure 1) was adopted for data collection. The details of framing of the questionnaire are discussed at 3.1.7. While surveying the villages the environmental, social and economic status was evaluated, discussed and details were recorded. Relevant photographs were also taken. The details of the study area are discussed below:

3.1 Study Area

Major part of the study area is located in the Majha and Malwa region of Punjab i.e. 29.30º to 32.32º North latitude and 73.55º to 76.50º East longitude. There are only three rivers namely Ravi, Beas and Sutlej that flow through this Indian state. Geographically these three rivers divide this triangular shaped state into three distinct regions: Majha (located between the Ravi and Beas rivers), Malwa (situated to the south of the Sutlej River), and Doaba (found between the Sutlej and Beas rivers). Geographically, Punjab shares its borders with Jammu and Kashmir to the north, Himachal Pradesh to the northeast, Pakistan to the west, Haryana and Rajasthan to the south. Notably, only Majha and Malwa regions share the international border, with six districts directly touching the border (Fig.3.1). The geographical characteristics of the state and its subtropical location result in significant variations in temperature, soil types, and climate. The soils are characterized as sandy with loose texture, alluvial and calcareous, with varying proportions of gravel, silt, sand and clay, (Bajwa *et al.*,2015). The list of names of border blocks per district covered during the survey are mentioned in the Table 3.1.

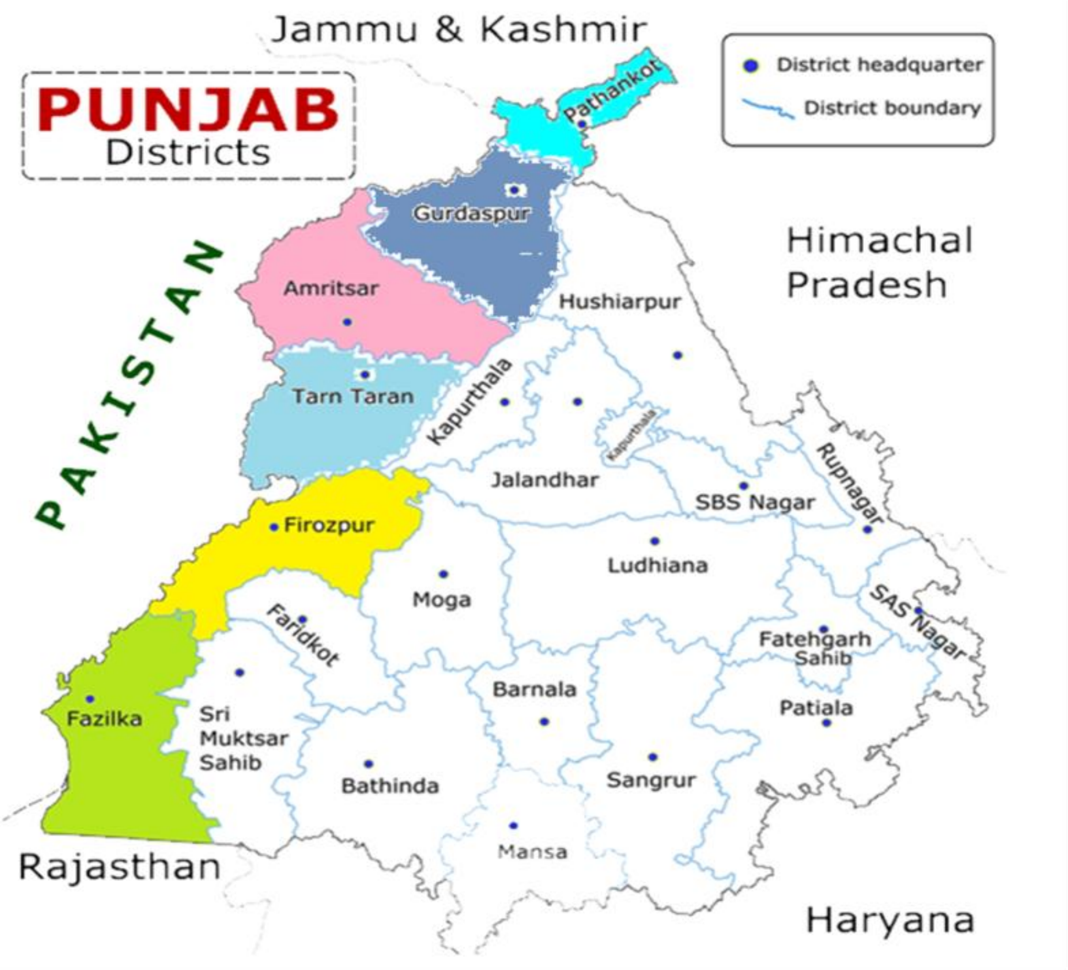


Fig. 3.1: Map of Study Area (Border districts highlighted)

The selected villages were marked on the map of Punjab (Fig. 3.2). A list of selected villages along with their respective district, the border block, the site code & geographical co-ordinates of the sample collection is mentioned in Table 3.2.

Table 3.1: List of Border Districts and their respective Border Blocks

S.No.	District	Number of Blocks	Name/s of the Block/s
1	Pathankot	2	Bamial, Narot Jaimal Singh
2	Gurdaspur	4	Dorangla, Kalanaur, Dera Baba Nanak, Dina Nagar
3	Amritsar	3	Ajnala, Chogawan, Attari
4	Tarn Taran	3	Bhikhiwind, Gandiwind, Valtoha
5	Ferozepur	3	Guru Har Sahai, Ferozepur, Mamdot
6	Fazilka	2	Jalalabad
Total	**6**	**17**	**17**

Table 3.2: List of Villages, border blocks and the geographical co-ordinates of sample locations

S. No.	District	Border Block	Village/Site	Site Code	Latitude °N	Longitude °E
1	**Pathankot**	Bamial	Khojki Chak	PKC	32.30711	75.3558
			Dhinda	PDH	32.31565	75.35489
		Narot Jaimal Singh	Paharipur	PPP	32.2338	75.3965
			Datyal	PDTL	32.22606	75.44286
2	**Gurdaspur**	Kalanaur	Gadi Kalan	GGK	32.092170	75.224210
			Dostpur	GDTP	32.078349	75.210243
		Dorangla	Bharath Qazi Chak	GBQCK	32.160596	75.420257
			Nadala	GND	32.115768	75.29117
		Dera Baba Nanak	Pakhoke	GPK	32.033871	75.037045
			Jaurian Kalan	GJKD	32.037146	75.01754
		Dina Nagar	Bala Pindi	GBLP	32.164054	75.392173
			Thundi	GTH	32.110434	75.2987
3	**Amritsar**	Chogawan	Ranian	ARNN	31.70809	74.5181
			Hetampura	AHM	31.73664	74.58981
		Attari	Bhakna Kalan	ABK	31.58263	74.7196
			Dhanoe Kalan	ADK	31.637143	74.557157
		Ajnala	Bohlian	ABH	31.82064	74.73327
			Bhindi Aulakh	ABA	31.821609	74.610938
4	**Tarn Taran**	Bhikhiwind	Dall	TDL	31.35098	74.57019
			Marhi Kamboke	TMK	31.321176	74.596411
		Valtoha	Kalia	TKL	31.236190	74.546630
			Wan Tara Singh	TWTS	31.36774	74.818545
		Gandiwind	Burj	TBJ	31.531494	74.642421
			Manakpur	TMPK	31.517386	74.710096
5	**Ferozepur**	Ferozepur	Bare Ke	FBKE	30.9707	74.5614
			Jhuggee Hazara	FHZ	31.014838	74.55566
		Guru Har Sahai	Jhuggee Shilian	FJSH	30.920516	74.610763
			Karman	FKRM	30.87651	74.47632
		Mamdot	Ruhela Haji	FROH	30.92878	74.48591
			Mamdot Hithar	FMMH	30.87651	74.55705
6	**Fazilka**	Fazilka	Asafwala	ZASF	30.38892	73.98357
			Mohar Jamsher	ZMJ	30.46758	73.93962
		Jalalabad	Ariyanwala	ZARNW	30.5819	74.28523
			Dhandi Qadim	ZDQ	30.62764	74.2017
Total	**6**	**17**	**34**	-	-	-

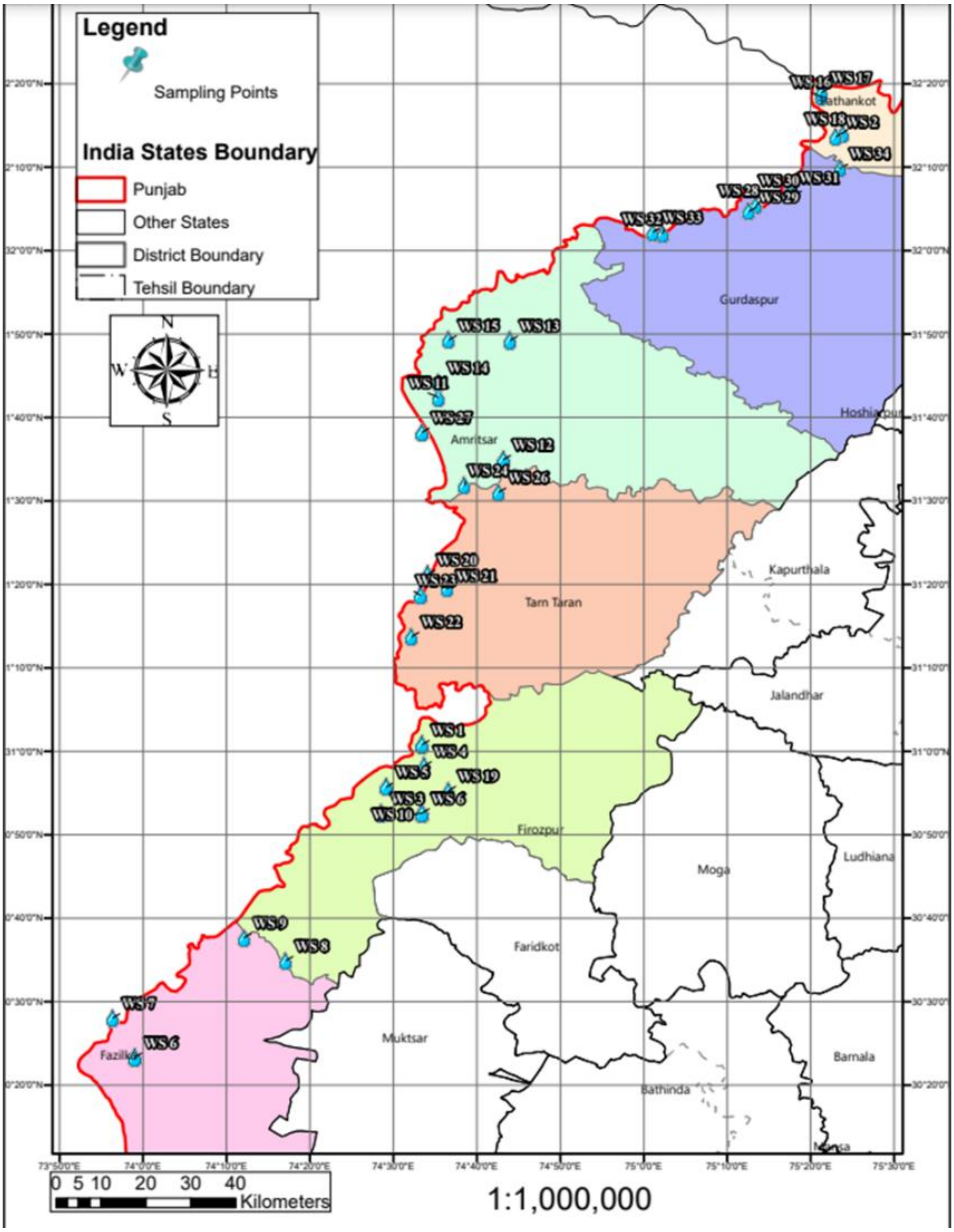


Fig. 3.2: Map of study area (with sampling sites)

The whole of Majha and some part of Malwa regions share international border with Pakistan. It is Wagah-Attari border in Majha region whereas Malwa region has the Hussaini Wala border and it is Sadiqui-Sulemanki border in District Ferozepur and Fazilka, respectively.

3.1.1 District Pathankot

Pathankot district, situated in the northern most part of the Indian state of Punjab (Fig. 3.3), was formed on 27 July 2011. It lies in the foothills of the Shivalik Hills and covers an area of 1089 sq.km. & has coordinates of 32.266814°N and 75.643444°E. This district shares its international border with Pakistan's Narowal District in the Punjab region. The prominent rivers Beas and Ravi traverse through the district. The soil composition is primarily sandy in the flood plains, gradually decreasing in quantity and coarseness in the upland areas. Pathankot district is divided into two sub-divisions: Pathankot and Dhar Kalan, along with two sub-tehsils or border blocks, Narot Jaimal Singh and Bamial. According to the 2011 census, the district has a total population of 676,598, with 378,432 as rural and 298,166 urban population. Pathankot has 860 females per 1000 males while Scheduled Castes make up 30.60% of the population. The villages that were surveyed from the two border blocks are in Table 3.3 as shown below:

Fig. 3.3. (Highlighted) study area of District Pathankot

Table 3.3: Villages of District Pathankot

S.No.	Border Block	Village
1	Bamial	Khojke Chak
2	Bamial	Dhinda
3	Narot Jaimal Singh	Paharipur
4	Narot Jaimal Singh	Datyal

3.1.1.1 Village Khojke Chak

Situated at an elevation of 284 meters above sea level, this village covers an area of 204 hectares and is located just 2 km from the international border (Fig. 3.4). According to the 2011 Census, the village is home to a population of 929 residents, with 471 males and 458 females. The literacy rate in the village is 74.64%, which is slightly

Fig. 3.4 Village Khojke Chak

below the state average of 75.84%. A significant portion of the population belongs to the Scheduled Caste (SC) community which constitutes 45.53 % of total population.

3.1.1.2 Village Dhinda

Spread in an area of 110 hectares, village Dhinda (Fig.3.5) is situated at 377 meters above sea level. It is at a distance of nearly 500 m from the international border and has small population of 206, comprising of 49.5% females and 50.5% males. The village has a literacy rate of 76.7%.

Fig. 3.5 Village Dhinda

3.1.1.3 Village Paharipur

Paharipur village is in border block of Narot Jaimal Singh and is nearly 1km from Pakistan border (Fig. 3.6). Situated at 269 meters above sea level and an area of 157 hectares, the village has a total population of 485 comprising of 50% females and 50% males. A substantial part of population comprises of SC category (32.78%). The village has a good literacy rate of 78.6%.

Fig. 3.6 Village Paharipur

3.1.1.4 Village Datyal

The village (Fig. 3.7) is spread over an area of 61 hectares and is at an elevation of 269 meters above sea level. Datyal has a population of 1,004, comprising of 536 males while females are 468 in number. The village has a good literacy rate of 70.62% and is at a distance of 6-7 km from the international border.

Fig. 3.7 Village Datyal

3.1.2 District Gurdaspur

Gurdaspur district, located in the Majha region of northern Punjab, is at the base of the Himalayan foothills and shares an international border with Pakistan's Narowal District, as shown in Fig. 3.8. This district has two significant rivers, the Beas and the Ravi. It holds historical importance as it is believed that the Mughal emperor Akbar was enthroned in a garden near Kalanaur, a town

Fig. 3.8 (Highlighted) Study area of District Gurdaspur

within the district. Geographically, Gurdaspur district has an elevation ranging from 225 to 294 meters above sea level, covering a total land area of 3,562 square kilometres. The district falls under the jurisdiction of the Jalandhar division and is situated between north latitudes 31°36' and 32°34' and east longitudes 74°56' and 75°24'. It shares its borders with Pakistan to the northwest.

As of the 2011 census, Gurdaspur district had a total population of 1,621,725, comprising of 1,260,572 rural and 361,153 of urban population. Scheduled Castes accounted for 23.03% of its population. It is the third most populous district in Punjab, with 31% of the total state population.

The villages selected randomly from district Gurdaspur are shown below in Table 3.4:

Table 3.4: Villages of District Gurdaspur

S.No.	Border Block	Villages
1	Kalanaur	Gadi Kalan
2	Kalanaur	Dostpur
3	Dorangla	Bharath Qazi Chak
4	Dorangla	Nadala
5	Dera Baba Nanak	Pakhoke
6	Dera Baba Nanak	Jaurian Kalan
7	Dina Nagar	Balapindi
8	Dina Nagar	Thundi

3.1.2.1 Village Gadi Kalan

Gadi Kalan village spans a total land area of 107 hectares and is inhabited by a population of 294 residents, comprising of 151 males and 143 females, as per 2011 census. The literacy rate was 67.82 % as compared to 75.84 % of state. The village is at a distance of less than 1 km away from the international border (Fig. 3.9).

Fig.3.9 Village Gadi Kalan

3.1.2.2 Village Dostpur

Dostpur village, depicted in Fig. 3.10, encompasses a total land area of 569 hectares and is situated at an elevation of 245 meters above sea level. It is home to a total population of 2,135 residents, consisting of 1,102 males and 1,033 females. The village boasts a good literacy rate of 61.41% and is almost 2 km from the line of defence.

Fig. 3.10 Village Dostpur

3.1.2.3 Village Bharath Qazi Chak

The village is nearly 8 km from the international border and is spread over an area of 426 hectares. This village (Fig.3.11) is situated at a height of 273 meters above sea level. The population of this village is 2629 out of which 1365 are males and rest are females.

Fig. 3.11 Village Bharath Qazi Chak

3.1.2.4 Village Nadala

Nadala village spans a total land area of 105 hectares and is situated at an altitude of 262 meters above sea level. Its population totals 181 residents, comprising 86 males and 95 females. The village has a literacy rate of 56.91%. This village is about 7.3 km from the international border (Fig.3.12).

Fig. 3.12 Village Nadala

3.1.2.5 Village Pakhoke

The village is situated 245 meters above sea level and is 2 km from the border. It has a population of 4344 out of which 2087 are females and rest are males. This village (Fig. 3.13) is spread over an area of 457 hectares and has a literacy rate of 57.4% which is much below the state literacy rate.

Fig. 3.13 Village Pakhoke

3.1.2.6 Village Jaurian Kalan

Fig. 3.14 Village Jaurian Kalan

Spread over an area of 346 hectares, it is situated at an altitude of 245 km above sea level. It has a population of 1,106 with 564 males and 542 females. The village has a literacy rate is 57.96% and is on the zero-line or the border line (Fig. 3.14).

3.1.2.7 Village Bala Pindi

Fig. 3.15 Village Bala Pindi

The village has a geographical area of 219 hectares and is 273 km above sea level. In a population of 1210, the village has 632 males while females are 578. It has a literacy rate of 76.94%. It is situated at a distance of 7km from the Pakistan border (Fig.3.15).

3.1.2.8 Village Thundi

Fig. 3.16 Village Thundi

The village has a geographical area of 97 hectares and is located at 262 meters above sea level. Thundi (Fig. 3.16) has a population of 640 residents, comprising of 323 males and 317 females. Literacy rate of the village is 74.22% and is just 2km away from the border.

3.1.3 District Amritsar

Fig. 3.17 (High-lighted) Study area of District Amritsar

District Amritsar (Fig. 3.17) falls in the Majha region of Punjab, is located between 31.35°N 74.59°E and is 219 meters above sea level. It is an important district of Majha region of Punjab. According to 2011 census it has a population of 2,490,656. The district has 4 tehsils out of which 2 of them are border tehsils. The western border of the district touches the international line of defence with Pakistan and River Ravi flows through the two nations near the border. The two border tehsils are Amritsar I and Amritsar II comprising of three border blocks/ community blocks namely Ajnala, Chogawan in Amritsar I and Attari from Amritsar II. From each border block two villages were selected at random as per the table 3.5 below:

Table 3.5: Villages of District Amritsar

S.No.	Border Block	Village
1	Ajnala	Bohlian
2	Ajnala	Bhindi Aulakh
3	Attari	Dhanoe Kalan
4	Attari	Bhakna Kalan
5	Chogawan	Hetampura
6	Chogawan	Ranian

3.1.3.1 Village Bohlian

Fig. 3.18a Village Bohlian

Fig. 3.18b Village Bohlian

A small hamlet of 455 hectares area (Fig.3.18a), it is about 12km away from the Indo-Pak border. With a population of 2062 (census 2011) at geographical coordinates 31.82214° N and 74.73407° E, the village is situated at 734 feet above sea level. It has 33% of the population comprising of schedule castes and has a literacy rate of 64.3%. Amongst the basic amenities the village has primary government school, an elementary private school, a small branch of IDBI Bank and a primary health centre. The sex ratio of the village is 849 which is higher than that of Punjab state i.e. 846. A few farmers also practice Agro-forestry (Fig.3.18b) and grow timber yielding Popular trees. Less than 1% of the population use Biogas as fuel for cooking and many people are into Dairy farming.

3.1.3.2 Village Bhindi Aulakh

It is in Ajnala block of Amritsar district (Fig.3.19). Located at coordinates latitude 31.64419°N and longitude 74.90364°E, the village has a population of 1198 with male female sex ratio of 836 which is lower than the ratio of Punjab. It is situated at an elevation of 735 feet above sea level and is spread over 681 hectares. The village has an upcoming stadium for the youngsters. It has two units of Milk cooperatives -Amul and Verka. The village has its own pharmacy and dispensary but the availability of doctors is an issue of concern.

Fig. 3.19 Village Bhindi Aulakh

3.1.3.3 Village Dhanoe Kalan

In Attari block of Amritsar District, the village is situated at 735 feet above sea level and is located at 32.00115°N 75.23785°E. It has an area of 577 hectares and a population of 1932 people. The village has a historic background with Maharaja Ranjit Singh and Indo-Pak War of 1965 and 1971. The Mosque, Mandir, Baradari and a Sarovar built by the Maharaja is an attraction for tourists. Whereas a war memorial, constructed in the memory of the Jawans of Sikh regiments, stands as a testimony to the supreme sacrifices (Fig.3.20).

Fig. 3.20 Village Dhanoe Kalan

3.1.3.4 Village Bhakna Kalan

This village is just 7 km away from the international border and is in Attari community block of District Amritsar (Fig. 3.21). It is located at 31.58119° N and 74.719674° E, covering an area of 524 hectares and has a population of 3264. Situated at an altitude of 732 feet above sea level, this village holds a significant place in history as a key contributor to freedom movement. It is renowned as the ancestral village of Baba Sohan Singh Bhakna, the founder President of Ghaddar party.

Fig. 3.21 Village Bhakna Kalan

3.1.3.5 Village Hetampura


Fig. 3.22 Village Hetampura

A small hamlet spread over an area of 391 hectares, the village is 4 km away from the border. It has a population of 1182 as per the 2011 census. With 31.73664°N and 74.589813°E location co-ordinates the village is at an elevation of 734 feet. The village has an inner fertile lowland surrounded by less fertile highland. The village has a good literacy rate (51%) and few people practice progressive farming. Farmers of the village showed some environment consciousness which is reflected through some healthy practices like use new equipment like Happy seeder that yield less stubble and thus lesser of stubble burning. A few of the households use non-conventional form of energy (biogas plants) as fuel for cooking. Farmers use manures more often than fertilizers to enhance soil fertility. Few farmers practice crop diversification and are also into dairy farming. The milk is collected and given to the Punjab Milk Cooperative, Verka. The village still has the traditional system of irrigation (Fig. 3.22)

3.1.3.6 Village Ranian

Fig. 3.23 Village Ranian

This village is very close to Indo-Pak border and is only 2 km away from it (Fig. 3.23). The village is located in Chogawan community block of Amritsar district at 31.70809°N and 74.5181°E co-ordinates. Spread over an area of 1077 hectares, it is situated at an elevation of 761 feet. It is a small village with only 1226 population (census 2011) comprising of 655 males and 571 females. A small portion of the village is under forest cover. To boost the income of villagers and provide livelihood, Amul cooperatives milk unit has been set up in the village. Due to poor shape of roads and inaccessibility, many commodities related to agriculture do not reach the village.

3.1.4 District Tarn Taran

Fig. 3.24 (Highlighted) Study area of District Tarn Taran

Tarn Taran district is in the Majha region of Punjab, India (Fig. 3.24). It got the status of a district in 2006, earlier it was a part of District Amritsar. The city of Tarn Taran Sahib is a holy place for Sikhs as Fifth Guru Shri Arjan Dev Ji laid the foundation stone of the city and the temple. The district has eight development blocks out of which three i.e. Bhikhiwind, Gandiwind and Valtoha are border blocks. As per 2011 census, it has a population of 1,119,627 and has 898 females for every 1000 males. The district has 69.4 percent literacy rate. The villages that were randomly surveyed are shown in Table 3.6 along with their respective border blocks.

Table 3.6: Villages of District Tarn Taran

S.No.	Border block	Village
1	Bhikhiwind	Dall
2	Bhikhiwind	Marhi Kamboke
3	Gandiwind	Burj
4	Gandiwind	Manakpur
5	Valtoha	Kalia
6	Valtoha	Wan Tara Singh

3.1.4.1 Village Dall

Spread in an area of 1540.89 hectares, the village is located at an altitude of 214 meters. The village has a total population of 4039 consisting of females. The literacy rate of the village is 50.06% and is just 2 km from the international border (Fig 3.25).

Fig. 3.25 Village Dall

3.1.4.2 Village Marhi Kamboke

Mari Kamboke village (Fig. 3.26), spans a total land area of 1,077 hectares and is situated at an elevation of 214 meters above sea level. The village is inhabited by a population of 3,929 residents, with 2,049 males and 1,880 females. The literacy rate is 54.75% and the village is nearly 6 km from the Indo-Pak border.

Fig. 3.26 Village Marhi Kamboke

3.1.4.3 Village Burj

The village covers a total land area of 319 hectares and is situated at an elevation of 224 meters above sea level (Fig.3.27). The village is a home to a population of 1,239 residents, with 654 being male and 585 females. The literacy rate in Burj is 54.00%, with 56.57% of males and 51.11% of females being literate. Notably, Burj is located 10 km away from the international border.

Fig. 3.27 Village Burj

3.1.4.4 Village Manakpur

It is 9 km away from the international border and has a geographical area (Fig. 3.28) of 317 hectares. It has an elevation of 224 meters above sea level. The population of the village is 1624 comprising of 878 males and 746 females. The literacy rate of this village is 59.05%.

Fig. 3.28 Village Manakpur

3.1.4.5 Village Kalia

This village (Fig.3.29) has a population of 1040 comprising of 45.4% females. The village has a literacy rate of 42.0%. It has a total geographical area of 396 hectares. It is situated at an altitude of 227 meters above sea level. It is 3 km away from the international border.

Fig.3.29 Village Kalia

3.1.4.6 Village Wan Tara Singh

It is nearly 2 km away from the international border (Fig. 3.30). It has an area of 1376 hectares and has a population of 3950 with 2084 males and 1866 females. Situated at an

Fig. 3.30 Village Wan Tara Singh

altitude of 224 km above sea level, the village has a literacy rate of 48.94%.

3.1.5 District Ferozepur

Ferozepur district (Fig. 3.31) is spread in an area of 2,407 sq.km. After its bifurcation into Fazilka district, it now has a total population of 1,001,931. It has a Scheduled Caste population of 42.85%. Geographically, it is situated at 30°56′24″N 74°37′12″E, and is in the south-western region of the State. This district is located at an elevation of 182 meters above sea level.

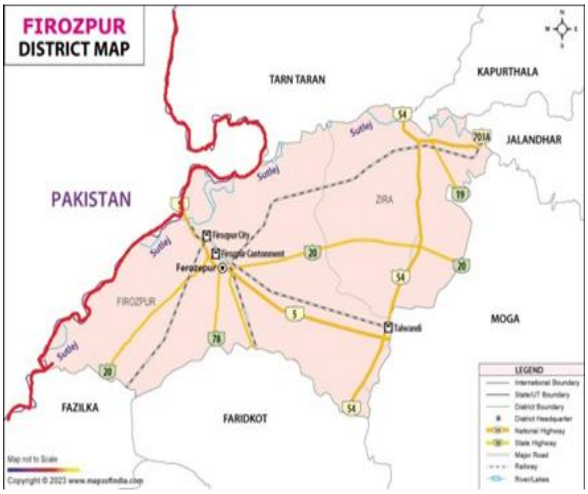


Fig. 3.31 (Highlighted) Study area of District Ferozepur

From the administrative perspective, the district falls under the jurisdiction of the Ferozepur division and is subdivided into 10 development blocks. Out of these, three blocks, namely Ferozepur, Guru Har Sahai and Mamdot, are positioned along the international border, thus comprising the border blocks of this district.

The Ferozepur district is situated within the Sutlej sub-basin of the primary Indus basin and features clusters of sand dunes. The terrain in this district is predominantly flat, sloping gently in the southwest direction. Sutlej, a perennial river, is the primary drainage system in the region, displaying both influent and effluent characteristics. Table 3.7 shows the list of villages randomly selected from the respective border blocks.

Table 3.7: Villages of District Ferozepur

S. No.	Border Block	Village
1	Ferozepur	Bare Ke
2	Ferozepur	Jhuggee Hazara
3	Guru Har Sahai	Jhuggee Shillian
4	Guru Har Sahai	Karman
5	Mamdot	Ruhela Haji
6	Mamdot	Mamdot Hithar

3.1.5.1 Village Bare Ke

Fig. 3.32 Village Bare Ke

The village has a population is 3583 with female population 48.4% and male population 51.6%. The village has a literacy rate of 43.8% and is spread over an area of 1225.58 hectares. Bare Ke (Fig. 3.32) is located 200m above sea level and is about 3 km from the international border.

3.1.5.2 Village Jhuggee Hazara

Fig. 3.33 Village Jhuggee Hazara

The village has a total geographical area of 623.23 hectares and is almost 500 meters from the international border. As per 2011 census, it has a population of 3,190 consisting of 50.6% males while female population is 49.4%. The village has a literacy rate of 52.32%, which is quite low as compared to the literacy rate of Punjab (Fig.3.33).

3.1.5.3 Village Jhugge Shillian

Fig. 3.34 Village Jhuggee Shillian

This village is located in Guru Har Sahai block and has a geographical area of 340.74 hectares. It is situated at a height of 199 meters above sea level (Fig. 3.34) and is 6 km away from the international line of defence. The village has a population of 512 as per 2011 census in which 54.5% is male population and rest 45.5% are females. The literacy rate of village is 61.9%.

3.1.5.4 Village Karman

Fig. 3.35 Village Karman

The village Karman, depicted in Fig. 3.35, covers a total land area of 832.05 hectares and is situated at an elevation of 200 meters above sea level. It is home to a population of 2,728 residents, with 1,427 males and 1,301 females as per 2011 census. The village has a literacy rate of 59.24%, with 62.58% of males and 55.57% females literate. Notably, it is located 7 km away from the international border.

3.1.5.5 Village Ruhela Haji

The village (Fig.3.36) has a total geographical area of 80.14 hectares and is situated at an altitude of 190 meters above sea level. Ruhela Haji has a total population of 634, with 321 males and 313 females. The literacy rate in of the village is 45.27% and is situated nearly five kilometres away from the international border.

Fig. 3.36 Village Ruhela Haji

3.1.5.6 Village Mamdot Hittar

Mamdot Hittar, as shown in Fig. 3.37, covers a total land area of 736.57 hectares and situated at an elevation of 199 meters above sea level. It is located approximately 6 km away from the border. This village is home to a total population of 6,242 residents, with 3,324 males and 2,918 females. With respect to literacy, the village boasts a literacy rate of 67.69%, having 70.85% of males and 64.08% of females are literate.

Fig. 3.37 Village Mamdot Hittar

3.1.6 District Fazilka

This district is in the Malwa region of Punjab (Fig. 3.38). It is located at 30.377614°N 74.129448°E coordinates and is spread over an area of 3113 sq.km. As per the 2011 census, it has a population of 1,027,143. Positioned adjacent to the Pakistan border, which lies to its west, Sutlej River flows through it and continues into Pakistan crossing the Indo-Pakistan border. Approximately 41.51% of its population belongs to the Scheduled Caste (SC) category.

The district is further divided into three tehsils, namely Fazilka, Abohar, and Jalalabad. Fazilka and Jalalabad are the border district tehsils. The table 3.8 below shows the details of the villages randomly selected from the district.

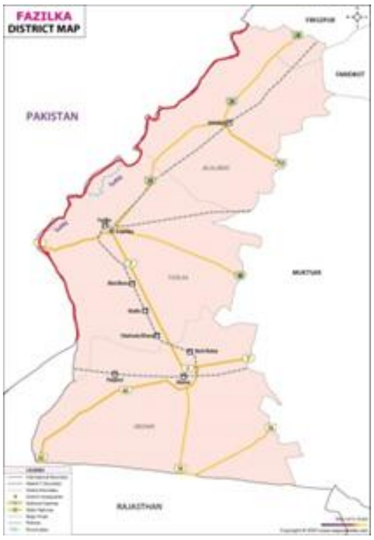


Fig. 3.38 (Highlighted Study area of District Fazilka

Table 3.8: Villages of District Fazilka

S.No.	Border Block	Village
1	Fazilka	Asaf Wala
2	Fazilka	Muhar Jamsher
3	Jalalabad	Ariyan Wala
4	Jalalabad	Dhandi Qadim

3.1.6.1 Village Asaf Wala

The village covers a total land area of 329 hectares and is at an elevation of 181 feet above sea level. It is situated approximately 4-5 kms away from the border (Fig.3.39). Asaf Wala is home to a population of 1,752 individuals, comprising 926 males and 826 females. In terms of education, the village has a literacy rate of 48.29%, with 56.59% of males and 38.98% of females being literate. For most of the economic activities, the nearest town to Asaf Wala village is Fazilka.

Fig. 3.39 Village Asaf Wala

3.1.6.2 Village Muhar Jamsher

Spread in 549 hectares, the village is just 500 m away from the international line (Fig. 3.40). It is located at 30.4812°N 73.93964°E. It is one of the two villages in India which is surrounded by Pakistan on three sides and by river Sutlej on the fourth side. Otherwise, a secluded village, it was connected with the Indian mainland for the first time in 2014 when a road bridge was constructed over river Sutlej. It has a population of 869 residents with 435 males and 434 females and a sex ratio of 846. The village literacy rate is 46.89% which is very low as compared to the state (75.84%).

Fig. 3.40 Village Muhar Jamsher

3.1.6.3 Village Ariyan Wala

This village encompasses a total land area of 433.33 hectares and is situated at an elevation of 577 feet above sea level. Ariyan Wala is home to a population of 1,007 residents, with 538 being males and 469 females. The village boasts of a literacy rate of 65.84%, with 71.93% of males and 58.85% of female are literate. It is located approximately 13 km away from the border (Fig. 3.41).

Fig. 3.41 Village Ariyan Wala

3.1.6.4 Village Dhandi Qadim

It is situated at an elevation of 610 feet and is nearly 4km away from the international border (Fig. 3.42). This village covers a total land area of 1148.94 hectares and is home to a population of 4,048 residents. It has a total of 2,091 males and 1,957 females. The village has a literacy rate of 53.56% which is higher in males 59.68% as compared to 47.01% females.

Fig. 3.42 Village Dhandi Qadim

3.1.7 Designing the Questionnaire

It is a research tool comprising of set of questions that are used to obtain information from the respondents. For collecting the primary data, a questionnaire was framed covering different aspects of rural development as per the objectives of the study. The questions were framed by taking into reference the village and household survey forms provided at the website of Unnat Bharat Abhiyan (UBA), a flagship programme of Ministry of Education (MoE), Government of India, (https://unnatbharatabhiyan.gov.in/view-forms). For this purpose, structured and unstructured questions were framed. Open ended, questions with multiple choice, dichotomous or scale response were included. From each village 15 respondents belonging to all age groups irrespective of the gender and occupation were randomly selected for filling the questionnaire. The responses so given helped in gathering an overall information about the respective village. Questions were based as follows:

1) Basic Information of the Respondents- demographic details like age, sex, education level, occupation.
2) Health and sanitation
3) Irrigation and water source
4) Financial and credit status
5) Socio-economic status
6) Environmental consciousness

Questions have been framed to collect information regarding various aspects of health and sanitation like drinking water supply, sanitation facilities, electricity facility, and assets (agriculture land) ownership, access to social services, rating of infrastructural and social facilities at destination place, environmental consciousness.

Pre-testing a questionnaire involves assessing it with a limited group of participants to refine it and identify the errors. It is best done by personal interview method. Questionnaire was first pre tested on 25 respondents. Accordingly, the questionnaire was slightly modified and some of the questions were reframed. The Questionnaire used in this study is given in Appendix 1. The households with different occupations were selected for the study purpose.

3.1.8 Methodology

From the six border districts under study, all respective border blocks were selected for survey and sample collection. A total of 17 border blocks (Table 1) were covered under survey and from each block two villages were chosen randomly. From each village 15 respondents were selected again at random. Thus, a total of 34 villages and 510 respondents were covered in this study.

All the above thirty-four villages were surveyed and the data for socio-economic issues was collected through group discussions and interviews. Questionnaires were distributed to fifteen respondents (at random) per village as discussed above. To evaluate the environmental consciousness of the villagers, questions were framed pertaining to the topic. The survey and questionnaire also helped in getting the demographic details of the selected villages. After the questionnaires were filled by respondents they were collected and subjected to further analysis. The broad outline of work plan has been shown below in Fig. 3.43.

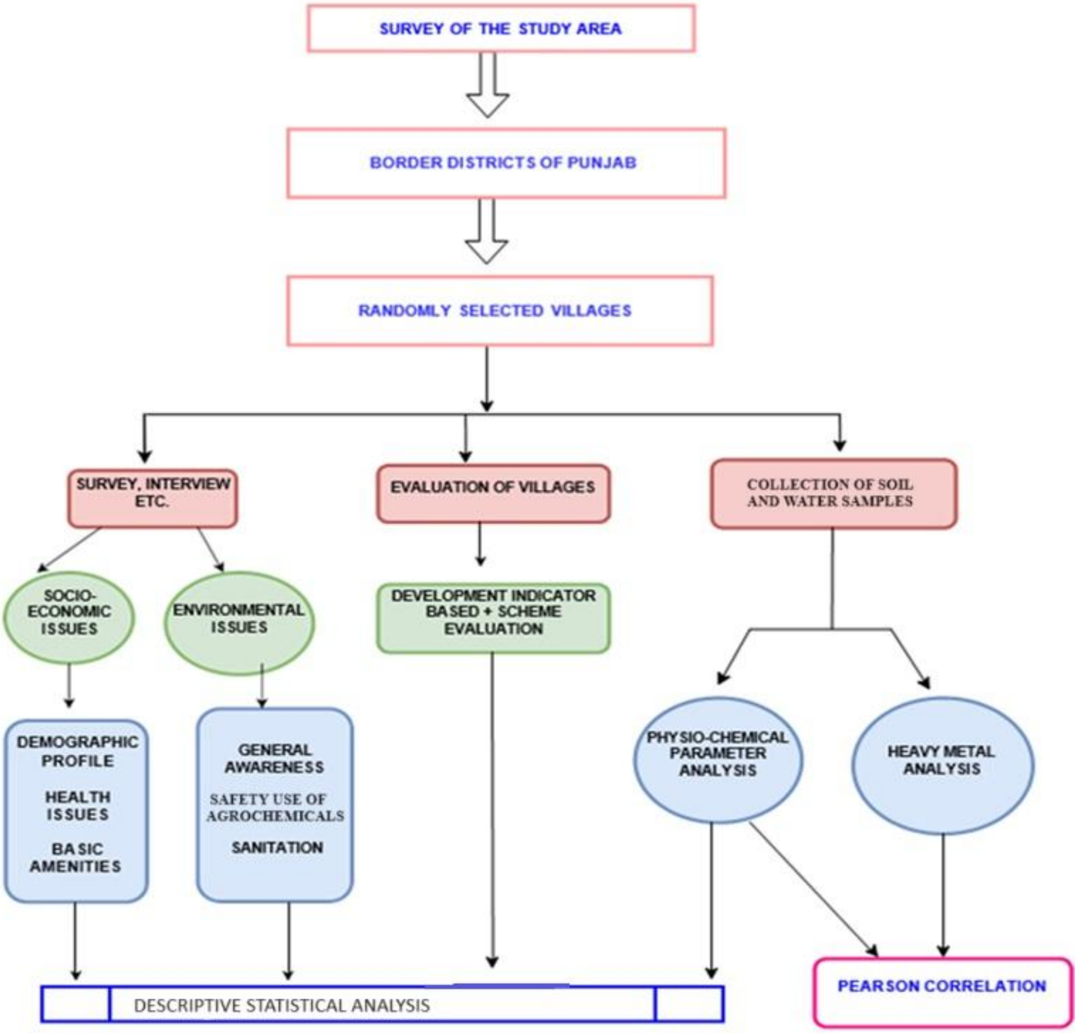


Fig. 3.43: Broad Outline of the work plan

Objective 2: Assessment of soil and water quality by monitoring the physio-chemical parameters and heavy metal analysis

Under this objective samples of soil and water were taken from all the chosen locations in the border belt of Punjab. To determine the quality of water and soil physico-chemical parameters and heavy metal analysis was conducted.

Samples of water were collected from different sources (tube wells, handpumps and taps) pertaining to the area under focus. It was allowed to run for 5-10 minutes prior to the collection in pre-washed sterile well labelled polyethylene bottles (triplicates). All the samples were then put in iceboxes and then kept at 4ºC in the laboratory till subjected to more investigations.

3.2 Physico-chemical parameters of Water samples

The physical and chemical variables of the water samples were estimated to check the quality of water. To collect the samples of ground water, tube-wells were allowed to run for a few minutes prior to collection in order to avoid water pipe contamination and stagnation in pipes and collected from locations near to the sites of soil sample collection. Water samples were collected in the fresh and clean polypropylene bottles, acidified with the conc. HNO3 and stored in refrigerator at 4 °C (APHA, 2005) till further analysis. The physical and chemical attributes (Table 3.9) were analysed as per the standard methods (APHA, 2005).

Table 3.9: Parameters used for physico-chemical analysis of water samples

S. No.	Parameters	Abbreviation	Units
1	pH	pH	--
2	Total Dissolved Solids	TDS	mg/L
3	Electrical Conductivity	EC	µS/cm
4	Total Hardness	TH	mg/L
5	Alkalinity	TA	mg/L
6	Fluoride	F^-	mg/L
7	Chloride	Cl^-	mg/L
8	Sulphates	SO_4^-	mg/L
9	Nitrates	NO_3^-	mg/L
10	Magnesium	Mg	mg/L

Parameters like pH, EC and TDS were measured with the help of pen type meters and other parameters like Chlorides, Fluorides, sulphates, nitrates and magnesium were estimated with ion chromatography. A part of the acidified water sample was filtered using Whatman 42 filter paper to determine heavy metals like Chromium (Cr), Nickel (Ni), Selenium (Se) etc. The results so obtained were compared with drinking water quality specifications of Bureau of India/WHO (BIS/WHO, 2012) as shown in table 3.10 given below:

Table 3.10: WHO/BIS standards of Heavy metals in water

S. No.	Heavy metal	Acceptable limit(mg/l)	Permissible limit(mg/l)
1	Arsenic	0.01	0.05
2	Cadmium	0.003	No relaxation
3	Chromium	0.05	No relaxation
4	Lead	0.01	No relaxation
5	Mercury	0.001	0.006
6	Nickel	0.02	No relaxation
7	Selenium	0.01	0.04
8	Uranium	0.01	0.03

3.2.1 pH

pH is the numeral measure of the acidity or alkalinity of a solution. It is a significant parameter that determines the corrosive nature of water. It was measured by using pen type pH meter (Hanna). Lower pH value indicates high corrosivity of water.

3.2.2 Total dissolved solids (TDS)

Total dissolved solids (TDS) are a metric for the total amount of inorganic and trace organic material found in water from both natural and artificial sources. A pen TDS metre was used to measure TDS of water. The units of measurement are milligrams per litre (mg/l).

3.2.3 Electrical conductivity (EC)

The electrical conductivity (EC) is equal to the number of electrolytes dissolved in water. EC was also determined by using the EC meter. The unit of EC is micromhos/cm (µS/cm) at 25ºC.

The concentration of charged particles in a liquid is determined using ion chromatography (IC) equipment. Proteins, anions, cations, and organic salts are among the particles that IC devices are able to examine. Inorganic cations and anions, as well as organic ions that enable ion separation in the sample and simultaneous quantification of inorganic anions and cations, complexes that carry charge, and organic materials that can exist in ionic form, are all determined using this widely used analytical technique. Comparing ion chromatography to other separation techniques, one of the main benefits is that there is only one interaction involved during the separation. The anions Chlorides, Fluorides, Sulphates, Nitrates and cations like Magnesium, total alkalinity and total hardness were estimated by Ion chromatography method. This estimation was carried out at the Regional Water Testing Laboratory (RWTLASR) Water Supply and Sanitation, Amritsar using Ion Chromatography (IC), Thermo Fisher Dionex Aquion following standard APHA-4110 and ISO 14911 methods.

3.2.4 Total alkalinity (TA)

Alkalinity is a measure of the acid neutralizing capacity of water. It represents carbonates, bicarbonates, hydroxides and 2/3rd of the phosphates present in the sample.

3.2.5 Total Hardness (TH)

The ability of water to react with soaps is known as its hardness, which is a measure of water quality. Carbonates and bicarbonates are produced when calcium and magnesium ions are dissolved in water. In addition to affecting the taste of water, it also increases soap and detergent usage and deposits scale in water heaters and pipes.

3.2.6. Chloride (Cl^-)

Chlorides are a part of salt; sodium chloride present in dissolved form in water. It is required in small amounts for cellular processes. Metals corroded by chlorides lose flavour, and so do food products. High chloride levels are toxic to aquatic life.

3.2.7 Fluoride (F^-)

Although fluorides are essential mineral for bone and teeth development but they are persistent and stay for longer duration in the ecosystem, even at low concentration. Thus, it is harmful at all trophic levels of the ecosystem.

3.2.8 Nitrates (NO_3^-)

It is one of the essential elements for all living things and the most readily assimilated form for plants. It supports the growth and is a vital plant nutrient. However, high nitrate concentrations in water can result in eutrophication.

3.2.9 Sulphates (SO_4^{2-})

Sulphates (SO_4 $^{-)}$ are present in water and are indicators of hardness. Their main source in water is through soils & rocks containing sulphates, atmosphere and industries. They are a part of various metabolic plant processes.

3.2.10 Magnesium (Mg)

Magnesium content in water is part of the total hardness estimation as discussed earlier in section 3.2.5.

3.3 Physico-chemical parameters of soil

Composite samples of soil were collected in well-labelled fresh polythene bags from all the 34 location sites or villages for further laboratory analysis. All variables like Bulk density, soil texture, total organic carbon, soil organic matter, pH, electrical conductivity, phosphorous, nitrogen and potassium content were carried out using different standard protocols (Olsen *et al.*,1954; Bremner and Mulvancey,1982; Trivedy *et al.*,2002; Jacob and Clarke *et al.*, 2002; Chand *et al.*,2011; Bhat *et al.*, 2014).

3.3.1 Preparation of soil extract

For analysing the physical and chemical variables, aqueous extracts of collected soil samples were prepared by following the below given steps (Fig 3.44):

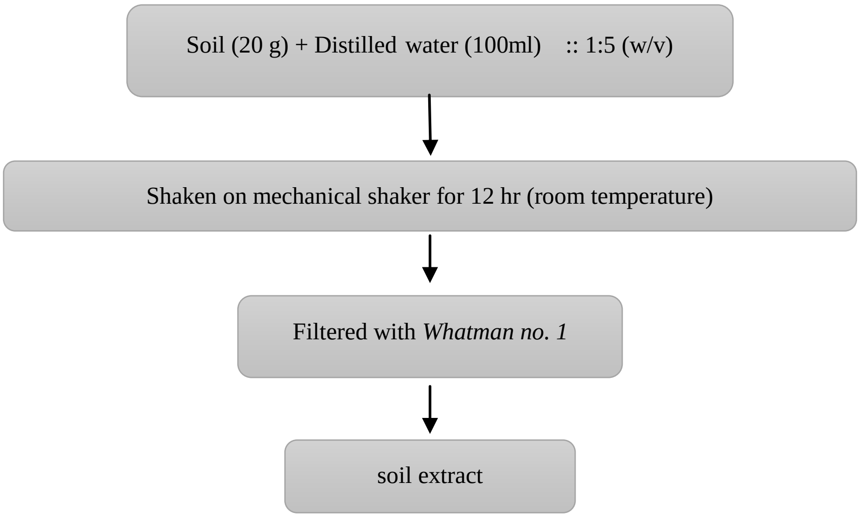


Fig. 3.44: Soil extract preparation

3.3.2 Soil texture

Soil texture, a significant property of soil, influences nutrient retention, leaching, and water holding capacity. It refers to the distribution of soil particles – namely sand, silt, and clay – within a sample. Different sized soil particles are grouped together, and the relative percentage of each category provides information about the texture of the soil. The various particle sizes from finer to coarser are as follows (Fig 3.45):

Clay <0.002mm, silt 0.002-0.5mm, sand 0.5-2.00mm

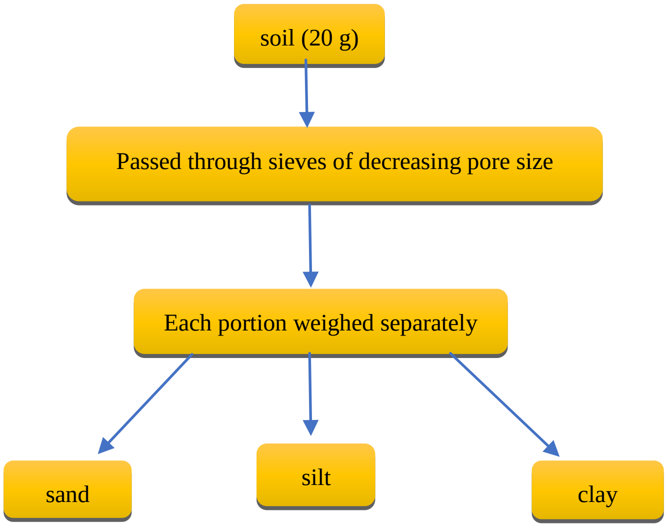


Fig. 3.45: Soil composition analysis

3.3.3 pH

To gauge the pH, the aqueous extract of soil sample was prepared as described in the section 3.3.1. pH meter (Hanna instruments)) was used to measure the pH of different soil extracts.

3.3.4 Moisture content (MC)

It is the proportion of weight of water to the weight of solids in a soil sample and was determined by Van Reeuwijk (2002).

An empty petri plate covered with a lid was weighted. Added 5 g of soil in the Petri plate, covered with lid and then weighed. The soil was dried in the petri plate after removing the lid, for 12 h in a hot air oven at 105°C. Removed the petri plate from oven, covered it with lid, cooled in a desiccator and weighed it again.

Moisture content (wt%) =$\frac{A-B}{B-P} \times 100$

Where; A = Weight of soil in covered petri plate, B =Weight of oven dried soil in covered Petri plate, and

P = Weight of covered empty Petri plate.

3.3.5 Electrical Conductivity (EC)

Electrical conductivity was estimated with the help of conductivity meter. Soil extracts of the various soil samples collected from the study area was used to measure EC. The unit of EC is micromhos/cm (µS/cm) at 25ºC.

3.3.6 Bulk density (BD)

Bulk density is a measure of mass per unit volume of soil. It indicates the compactness, wetness and porosity of the soil. It is a critical factor for plant growth but excessive bulk density can hinder root penetration in soil (Rai *et al.,* 2010). It was measured using cylinder method (Jacob and Clarke, 2002; Nemati *et al.,* 2012) and prepared by taking 25 g of air-dried soil in a 100 ml measuring cylinder and the volume of the soil occupied in the measuring cylinder was noted.

$$Bulk\ Density\ \left({}^{g}/_{cm^3}\right) = \frac{Weight\ of\ the\ soil\ taken}{Volume\ of\ the\ soil\ in\ measuring\ cylinder}$$

3.3.7 Soil organic carbon

Being the main source of energy and nutrients, total organic carbon, also known as soil organic carbon (SOC), is a crucial factor that influences plant growth. By enhancing mineralization, it promotes nutrient bioavailability and boosts water retaining capacity. An increase in SOM/SOC leads to increased biodiversity. Dry combustion method (Nelson and Sommers, 1982) was followed to estimate total organic carbon content of the soil samples and is given below in Fig 3.46:

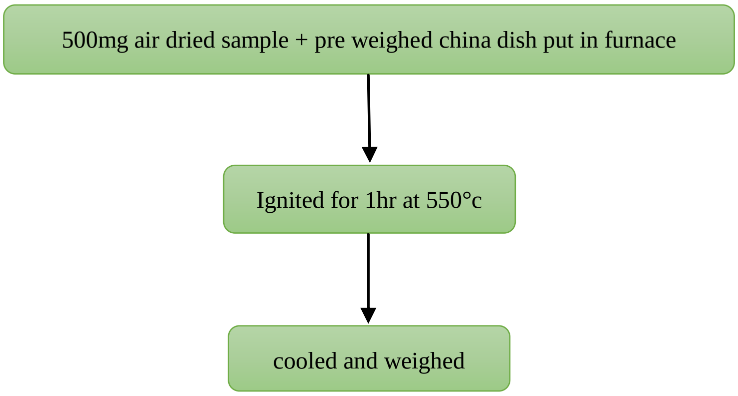


Fig. 3.46: Estimation of Total Organic Carbon

$$Ash\ \% = \frac{Weight\ of\ sample\ left\ after\ ignition\ \times 100}{Weight\ of\ sample\ taken}$$

$$TOC\% = \frac{100 - Weight\ of\ sample\ left\ after\ ignition\ \times 100}{Weight\ of\ sample\ taken}$$

$$TOC(\%) = \frac{100 - ash(\%)}{1.724^{*}}$$

$$SOC = \frac{100}{SOM(0.58)}$$

*a Van Bemmelen factor (Van Bemmelen, 1891):

The standard practice for transforming soil organic matter (SOM) data into soil organic carbon (SOC) data typically involves applying the van Bemmelen factor, which is 0.58, or its reciprocal, 1.724, as a universally recognized conversion factor

3.3.8 Soil Organic matter (SOM)

Fertility of soil is determined by the presence or percentage of organic matter. All kinds of dead decaying matter of plant and animal origin contribute towards it. (Donahue, T.M., 1971). It was estimated by following the loss on ignition method (Andersen and Krysell,2005)

A crucible was heated at 550° C for half an hour in a muffle furnace. Cooled it in desiccator and then weighted it. Took 0.5 g of oven dried soil sample in the crucible and put it in furnace at 550°C for one hour till the soil turns into ash. Again, cooled the crucible with ash in the desiccator, to room temperature and weighed.

Ash (%) =$\frac{W2-W1}{W3-W1} \times 100$

Where; W1 = Weight of empty crucible (g),

W2 = Weight of crucible + soil sample (g), and

W3 = Weight of crucible + ash (g).

Soil organic matter % = 100 – Ash (%) W

3.3.9 Total Nitrogen

Nitrogen, an important component of chlorophyll and amino acids, is a vital element for the growth of plants (Velmurugan *et al.*, 2012). It was determined by using the Kjeldahl method (Fig. 3.47) that involves digestion, distillation, titration.

$$\mathbf{\% \ N =} \frac{(a - b) \times \text{N of HCl} \times 1.4}{\text{Weight of sample}}$$

where,

a = volume (HCl) used for sample (ml)

b = volume (HCl) used for blank (ml)

1.4 = multiplication factor

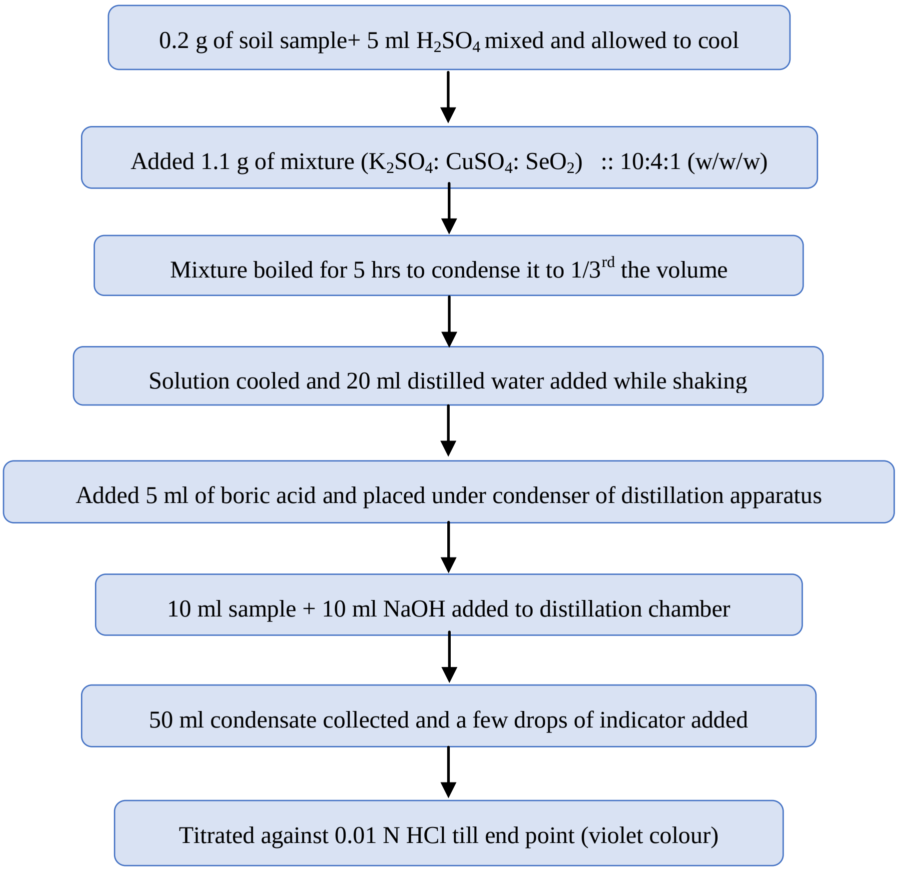


Fig. 3.47: Estimation of Nitrogen by Kjeldhal method

3.3.10 Total available phosphorous (TAP)

Phosphorus is another important mineral for the plant growth and is available in the form of phosphate ions. It is essential for growth, healthy roots and fruiting in plants. The method of analysis given by Olsen *et al.*, 1954 is shown in Fig 3.48. The absorbance was recorded at 720 nm using spectrophotometer (Type: 2202, Systronics, India).

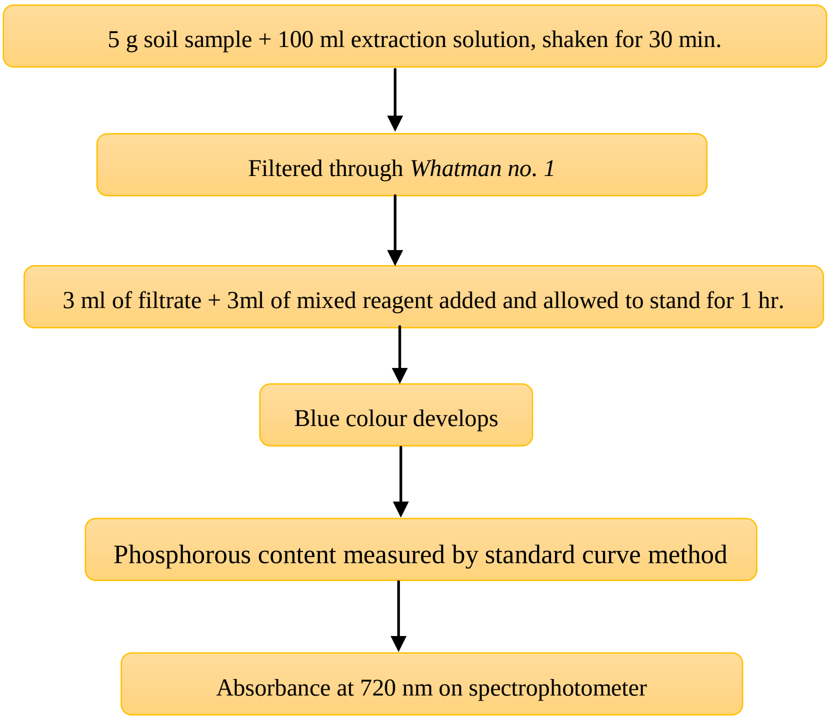


Fig. 3.48: Estimation of Phosphorus

3.3.11 Total potassium

Potassium is another element of importance for plants because of its role in regulation of the opening and closing of stomata during transpiration. It helps the plants in efficient use of water & provides resistance to drought & diseases.

Dissolve 1.907g of potassium chloride in 1 litre of distilled water. Then by serial dilutions of the stock solution concentrations of 20, 40, 60, 80 and 100 mg were prepared. The soil extract was prepared by digesting 0.5g of air-dried soil in 15ml of aqua regia. It was diluted with 20ml of distilled water. This extract was then aspirated into flame photometer. (Systronics-178; model ElicoCL26D). The optical density was taken at 768 nm and standard curve was obtained by taking optical density on Y axis and potassium concentration on X axis.

3.3.11.1 Principle of flame photometer

The aqueous extract of soil sample is aspirated in the form of a fine spray into a flame. The solvent evaporates from the sample after exposure to the flame leaving behind the dehydrated salt. Under high temperature, this dehydrated salt dissociates transforming into gaseous atoms in their lowest energy state, these atoms absorb energy from the flame. Upon getting energized, these atoms subsequently release radiation of a distinct wavelength as they transition back to their original energy state. This emitted radiation is quantified using a photocell/detector arrangement (Trivedy *et al.,* 2002).

3.4 Elemental analysis/ Heavy metal analysis

Plants require metals like Mg, Ca, Mn, Zn, K, Fe for various physiological & metabolic activities but in moderation. These are called essential metals. If their concentration goes beyond the minimum required limit, they show toxic effects also e.g. Zn. Moreover, abundance of any of the metal may lead to deficiency of another metal. These essential metals also compete with toxic heavy metals during cation exchange for the translocation to plant.

Heavy metals can be classified either according to their physical and chemical attributes or their potential toxicity to living organisms. The predominant definition of heavy metals primarily based on their physical characteristics is, “Metals having density higher than 3.5 g/cm^3” (Duffus, 2002). Heavy metals are the metals which are toxic to plants even at lowest concentration except copper and cobalt.

Therefore, estimation of heavy metals like mercury (Hg), uranium (U), iron (Fe), cadmium (Cd), chromium (Cr), nickel (Ni), and selenium (Se) and Arsenic (As) was carried out in the collected samples of water and soil. Heavy metal analysis was carried out with Microwave Plasma Atomic Emission Spectroscopy (MPAES) Agilent 4200 at Khalsa College, Amritsar and (ICP-MS) Inductively Coupled- Plasma Mass Spectrophotometer (Agilent model-7800) at Regional Water Testing Lab (RWTLASR), Water Supply and Sanitation, Amritsar.

3.4.1 Principle of Inductively Coupled Plasma Mass Spectrophotometer

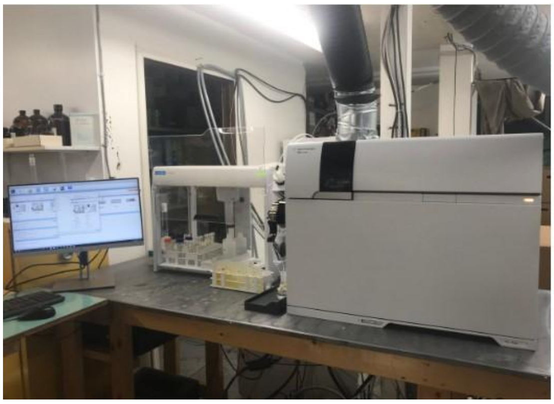


Fig. 3.49: Inductively Coupled Plasma Mass Spectrophotometer

Argon is converted into a gas or plasma in ICP-MS that is composed of electrons, ions, and neutral particles (Fig. 3.49). The elements in the sample are atomized and ionised by the plasma, and the resultant ions are then channelled through seven cone-shaped perforations from a region of high temperature into the higher vacuum and leading to mass analyser. It is a method for determining extremely low quantities of elements, such as those in the ppb range. Atomic elements are passed through a plasma generator where they ionise and are subsequently sorted based on their mass.

3.4.2 Principle of MPAES

Fig. 3.50: *Microwave Plasma Atomic Emission Spectroscopy*

It is an atomic emission technique that uses the fact that an excited atom of a particular element emits light in a defined wavelength pattern when it returns to its ground state. Plasma is created from nitrogen using microwave radiation from an industrial magnetron. MPAES mains run on air (Fig 3.50).

Objective 3: Identify the Local problems specific of the Villages under study

One of the major drawbacks of the villages under taken for study is their location itself. Being situated near the international border is a serious problem due to which they are always at a disadvantage. To have an insight into the individual problems the villages were surveyed to get a first-hand information of the different aspects of village life. Some villagers along with the village head were selected randomly and were interviewed. Different questions related to various aspects of the village life were asked and the responses were recorded. Several rural issues were discussed that brought to light the problems/issues of the villages. For this purpose, villages were toured with the help of the local people and various problematic areas were visited.

Objective 4: Evaluation of villages based on development and under various development schemes.

During the survey of villages certain common parameters were chosen as indicators of development which were considered for their evaluation. A total of 21 indicators were taken and divided on a 3 Point Scale as given below in Table 3.11.

Table 3.11: Village Grading system on the basis of Development Indicator availability*

S. No.	No. of Indicators available	% score	Grade of the village
1	< or = 7	33.3	C
2	8-14	66.6	B
3	15 and above	90	A

*Adapted (pib.gov.2023)

This evaluation has been done in accordance with the Panchayat Development Index (PDI) that has been standardized by the Ministry of Panchayati Raj (pib.gov.2023). The aim of this mission is Localization of Sustainable Development Goals (LSDG's) in PRI's (Panchayati Raj Institutions) and is part of the revamped Rashtriya Gram Swaraj Abhiyan (2018). The grading has been done with an emphasis on local indicators and the local targets of the villages. This assessment that would help the state and centre governments to know the gap between the actual implementation & impact of various rural development schemes. It would also bring into focus the neglected areas/aspects of rural development which need special attention for improvement.

To represent the availability of the local indicators, a gradation of three different colours has been chosen on a three-point scale (Table 3.12) considering the distance as the criteria on the following basis:

Table 3.12: Distance of indicator availability and its representation

S.No.	Distance of indicator availability	Colour
a)	If the indicator is present within (0-2 km) the village under study, it is represented with green colour	🟢○○
b)	If the indicator is available within a distance of 2-5 km from the village, then it is represented with yellow colour.	○🟡○
c)	When the indicator chosen for evaluation is available within a distance of 5-10 kms or is not available in the near vicinity it is represented with red colour. It means there is a critical gap in the availability of that particular indicator.	○○🔴

CHAPTER 4

RESULTS

4.1 Objective 1

4.1.1 Socio-economic Issues

The study was surveyed to collect information regarding the socioeconomic status of the villagers. From the six Border districts 34 villages were randomly surveyed and the data was collected from 510 random respondents. Amongst the respondents there were 451 males and 59 females. Amongst the females, 18 were illiterate 17 under matric and 13 females were matriculate. One female was there in each of the graduate and postgraduate category. The respondents were of different educational level, illiterate to postgraduate who were in the age group of 25 years to 55 years and above. These respondents had a monthly income ranging from Rs 5000 to Rs 20,000 and above depending on their occupation. Agriculture, shopkeepers/ business, service class, labour etc. were the major occupations of these respondents. The respondents had land holdings of different sizes (1 acre to 20 acres or above). During investigation it was found that many respondents suffered from certain health issues like blood pressure, diabetes, liver disease, knee problems, etc. but at the same time some of were healthy or had no health issues. As income resources are limited, the respondents indicated that money is often taken on credit from sources like banks, relatives, money lenders etc. Information related to the availability of basic infrastructure and amenities like roads, streetlights, community halls, infrastructure related to education, health & sanitation as well as environmental consciousness especially the use and safe use of agrochemicals, practices like stubble burning, dumping of waste, crop rotation etc. was gathered both from the respondents as well as through the survey of the villages. The information related to the above stated socioeconomic issues has been presented in tabulated form as shown below from Table 4.1-4.13 and Fig.4.1-4.8.

4.1.1.1 Basic Infrastructure

It includes basic amenities like metalled roads, cemented streets & drains, community hall, sports facilities etc. The data was compiled in Table 4.1.

It is evident that majority (85.2%) of these villages under study have metalled road facility. The drains and internal streets are cemented in 73.5% of the villages with maximum percentage (83.3%) in District Tarn Taran. The availability of community hall and street light(solar) facilities were highest (75%) in Fazilka district while it was lowest (37.5%) in District Gurdaspur. The data reveals that sports facilities in all the villages under study makes up to 35.3% which is highest (50%) in Tarn Taran district.

Table 4.1: Basic Amenities availability in selected Border Districts

S. No.	District	No. of Villages surveyed	No. of Villages with Basic Amenities				
			Metalled roads	Streets & drains	Community hall	Sports facility	Street lights
1	Pathankot	4	3 (75)	3 (75)	2 (50)	1 (25)	2 (50)
2	Gurdaspur	8	6(75)	6(75)	4 (50)	3 (37.5)	3 (37.5)
3	Amritsar	6	5 (83.3)	4(66.6)	4(66.6)	2(33.3)	3 (50)
4	Tarn Taran	6	6 (100)	5 (83.3)	4 (66.6)	3 (50)	4 (66.6)
5	Ferozepur	6	5 (83.3)	4 (66.6)	4 (50)	2 (33.3)	3(50)
6	Fazilka	4	4 (100)	3 (75)	3(75)	1 (25)	3(75)
Total	**6**	**34**	**29 (85.2)**	**25(73.5)**	**21(61.7)**	**12(35.3)**	**18(52.9)**

Source: Field study (percentage in parentheses)

4.1.1.2 Basic Education Infrastructure

In this work under taken, an earnest effort has been made to observe the availability of basic education infrastructure in the border villages of Punjab. The data shows that all the villages had Anganwadi centres for the pre-schooling kids. Highest number of Anganwadi's are in district Gurdaspur (30.30%) and lowest in Fazilka (9.09%). Primary schools are also available in all (100%) the villages with district Gurdaspur leading (27.8%) and the lowest in district Fazilka and Pathankot (11.1%). Whereas the number of villages having middle and high schools is 82.35% and 29.4% respectively. District Gurdaspur has the maximum number of middle schools (25%) and the lowest number are in Fazilka and Pathankot district (10.71%). The details are in Table 4.2 and Fig 4.1 as shown below:

Table 4.2: Basic Education Infrastructure in Selected Border Districts

S. No.	District	No. of Villages with Amenities				
		No. of Villages surveyed	Anganwadi centre	Primary school	Middle school	Secondary school
1	Pathankot	4	4 (12.12)	4 (11.1)	3 (10.71)	1 (10)
2	Gurdaspur	8	10 (30.30)	10(27.78)	7 (25)	2(20)
3	Amritsar	6	5 (15.15)	6 (16.67)	5 (17.8)	2 (20)
4	Tarn Taran	6	6 (18.2)	6 (16.67)	5 (17.8)	2 (20)
5	Ferozepur	6	5 (15.15)	6 (16.67)	5 (17.8)	2 (20)
6	Fazilka	4	3 (9.09)	4 (11.1)	3 (10.71)	1 (10)
Total	**6**	**34**	**33 (97)**	**36 (>100)**	**28 (82.35)**	**10 (29.4)**

Source: Field Survey (Percentage in parentheses)

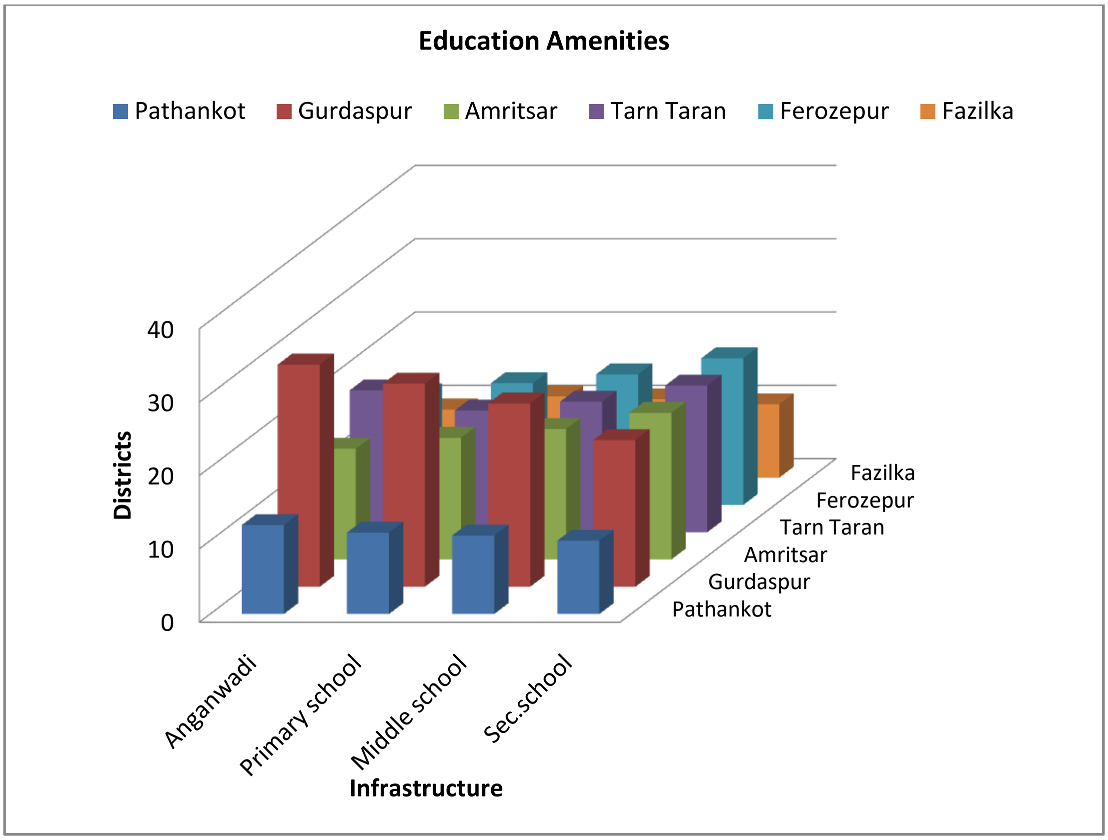


Fig. 4.1: Basic Education Infrastructure Availability in Selected Border Districts

4.1.1.3 Health and sanitation facilities

The data related to the facilities of Basic Health like availability of medical facilities in the form of hospital or dispensary, clean drinking water and veterinary hospital were analysed in the study area. The details collected were tabulated in Table 4.3. & Fig. 4.2. It shows that 70.5% of the villages have a hospital or dispensary. Both districts, Gurdaspur and Tarn Taran have the highest number of this facility (20.8%) while District Fazilka and Pathankot is worst affected with only 12.5% villages having a hospital or a dispensary. Veterinary hospitals are present in 35.3% of the villages. Two districts i.e. Gurdaspur and Tarn Taran are at par w.r.t. the availability of veterinary hospitals (25%). District Fazilka and Pathankot are the worst affected with 8.3% veterinary facility for the domesticated animals. Municipal Water or the drinking water facility is available in 85.3% of the villages with least percentage (10.34%) in Fazilka district. District Gurdaspur and Tarn Taran have the highest percentage of the facility (20.68%).

Table 4.3: Basic amenities (Health and drinking water facilities) in Border Districts

S.No.	District	No. of Villages with Amenities			
		No. of Villages Surveyed	Hospital / Dispensary	Veterinary Hospital	Water supply
1	Pathankot	4	3 (12.5)	1 (8.3)	4 (13.79)
2	Gurdaspur	8	5 (20.8)	3 (25)	6 (20.68)
3	Amritsar	6	4 (16.6)	2 (16.6)	5 (17.24)
4	Tarn Taran	6	5 (20.8)	3 (25)	6 (20.68)
5	Ferozepur	6	4 (16.6)	2 (16.6)	5 (17.24)
6	Fazilka	4	3 (12.5)	1 (8.3)	3 (10.34)
Total	**6**	**34**	**24 (70.5)**	**12 (35.3)**	**29 (85.3)**

Source: Field Survey (Percentage in parentheses)

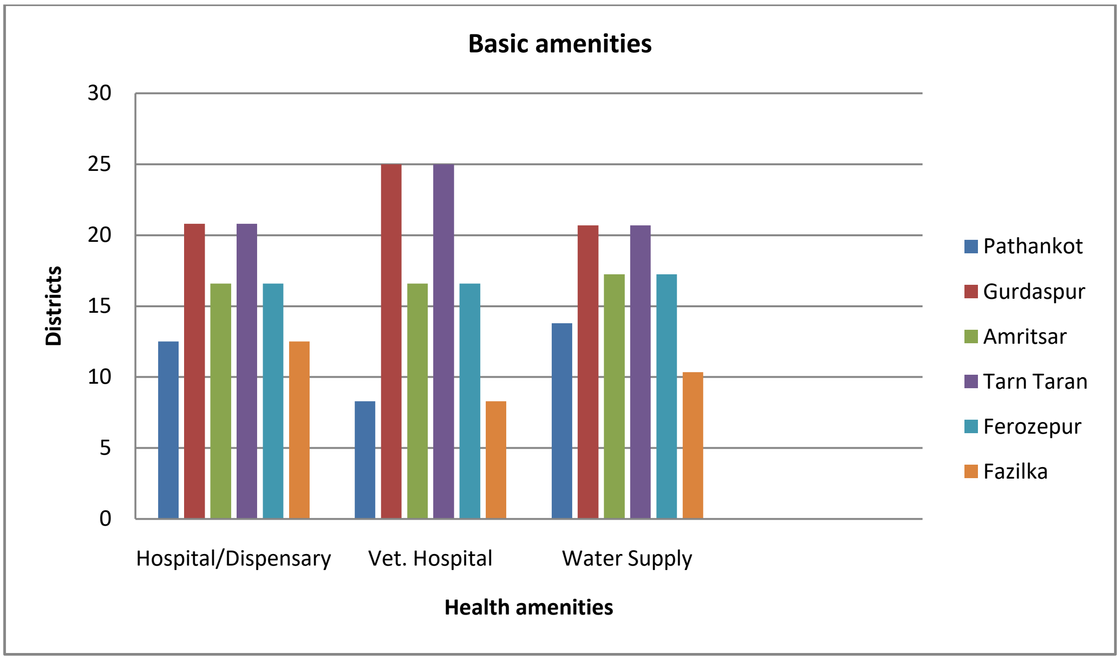


Fig. 4.2: Basic amenities (Health and drinking water facilities) availability in Border Districts

4.1.1.4 Education level of respondents

As per the observations, maximum illiterate respondents were in district Ferozepur (27.7%) and minimum (14.4%) is in Tarn Taran. The maximum number of matriculates are in District Pathankot (38.3%) and least are found in district Fazilka (23.3%). Similarly maximum number of graduates are found in district Amritsar (11.1%) and minimum (4.4%) in Ferozepur district. The education level of the residents in the villages surveyed as shown in Table 4. 4, indicates that most of them are matriculate (29.4%) followed by illiterate (21.3%) population. Least percentage is that of graduates (8.03%) and Post graduates (6.2%).

Table 4.4: Education Level – Distribution of respondents in Border Districts

Education Level	Districts-wise numbers of villages						Total
	Pathankot	Gurdaspur	Amritsar	Tarn Taran	Ferozepur	Fazilka	
Illiterate	11 (18.3)	33 (27.5)	14 (15.5)	13 (14.4)	25 (27.7)	13 (21.6)	109 (21.3)
Under Matric	5 (8.3)	15 (12.5)	16 (17.7)	13 (14.4)	18 (20.0)	13 (21.6)	80 (15.6)
Matric	23 (38.3)	30 (25)	34 (37.7)	27 (30)	22 (24.4)	14 (23.3)	150 (29.4)
10+2	9 (15.0)	24 (20.0)	10 (11.1)	25 (27.7)	17 (18.9)	13 (21.6)	98 (19.2)
Graduation	6 (10)	10 (8.3)	10 (11.1)	8 (8.9)	4 (4.4)	3 (5.0)	41 (8.03)
Post-Graduation	6 (10)	8 (6.6)	6 (6.6)	4 (4.4)	4 (4.4)	4 (6.7)	32 (6.2)
Total	**60 (100.0)**	**120 (100.0)**	**90 (100.0)**	**90 (100.0)**	**90 (100.0)**	**60(100.0)**	**510(100.0)**

Source: Field Survey (Percentage in parentheses)

4.1.1.5 Age of the respondents

During the survey the randomly selected respondents of the study area were of different age groups and the details are presented in Table 4.5. It is evident that District Gurdaspur has the highest (37.5%) percentage of mature and stable population i.e. 46-55 years of age and it is lowest in Fazilka and Amritsar (30%). The age group of 25-35 years has highest percentage in Fazilka 13.3% and is lowest in Ferozepur district 4.4%. The age group of 36 to 45 years is highest in Ferozepur District 37.8%. Overall, majority of the community in the area under investigation is in the age group of 46-55years (33.3%). and the least is in the age group of 25-35 years age group (9.4%).

Table 4.5: Age-wise composition of respondents in Border Villages of Punjab

Age (in years)	Districts-wise numbers of villages						Total
	Pathankot	Gurdaspur	Amritsar	Tarn Taran	Ferozepur	Fazilka	
25-35	6 (10)	13 (10.8)	11 (12.2)	7 (7.8)	3 (4.4)	8 (13.3)	48 (9.4)
36-45	14 (23.3)	32 (26.7)	24 (26.6)	29 (32.2)	34 (37.8)	19 (31.6)	152 (29.8)
46-55	22 (36.7)	45 (37.5)	27 (30)	28 (31.1)	30 (33.3)	18 (30)	170 (33.3)
Above 55	18 (30)	30 (25.0)	28 (31.1)	26 (28.9)	23 (25.5)	15 (25)	140 (27.4)
Total	**60 (100.0)**	**120 (100.0)**	**90 (100.0)**	**90 (100.0)**	**90 (100.0)**	**60 (100.0)**	**510(100.0)**

Source: Field Survey (Percentage in parentheses)

4.1.1.6 Occupation of respondents

Occupation wise the respondents surveyed were engaged in different occupations to earn their livelihood. Table 4.6 clearly depicts that except district Fazilka, where business/shopkeepers have the highest percentage (33.3%). The highest percentage of agriculturalists are in district Tarn Taran (61.1%). Maximum percentage of people in service/job are in Fazilka District 16.7% and minimum are in Tarn Taran district 6.7%. The percentage of people engaged in Labour as occupation is maximum in

Gurdaspur district 34.2% and minimum in Tarn Taran district 22.2%. It is agriculture (46%) predominantly as the main occupation of the people followed by Labour (28.82%) and shopkeeper/business (14.11%) as the second and third important occupation respectively.

Table 4.6: Occupation structure of respondents in Border Districts

Occupation	Districts-wise numbers of villages						Total
	Pathankot	Gurdaspur	Amritsar	Tarn Taran	Ferozepur	Fazilka	
Agriculture	29 (48.3)	53 (44.2)	46 (51.3)	55 (61.1)	37 (41.1)	15 (25.0)	235 (46. 0)
Shopkeeper/ Business	8 (13.3)	11 (9.1)	10 (11.1)	7 (7.8)	16 (17.8)	20 (33.3)	72 (14.11)
Service	6 (10.0)	15 (12.5)	9 (10)	6 (6.7)	8 (8.9)	10 (16.7)	54 (10.6)
Labour	17 (28.3)	41 (34.2)	25 (27.8)	20 (22.2)	29 (32.2)	15 (25.0)	147(28.82)
Others	0	0	0	2 (2.2)	0 (0)	0	2 (0.39)
Total	**60 (100.0)**	**120 (100.0)**	**90 (100.0)**	**90 (100.0)**	**90 (100.0)**	**60 (100.0)**	**510 (100.0)**

Source: Field Survey (Percentage in parentheses)

4.1.1.7 Income-wise distribution

As all the respondents earn their livelihood through different occupations so there is variation in their monthly income. Majority of the respondents (32.9%) surveyed falls in the income group of Rs 5000/ month followed by income group of Rs 5100-10,000 (30%) as presented in Table 4.7 & Fig. 4.3. Gurdaspur district has maximum percentage of people earning up to Rs 20,000/month (31.6%). District Tarn Taran has 31.1% of the population earning above Rs 20,000/ month. Amritsar dominates (37.8%) the income group of Rs 5100 to 10,000 per month. Gurdaspur on an average has Rs 11,000 to 20,000 of earning per month (31.6%). Ferozepur has 46.6% of population with the monthly income of up to Rs 5000 and district Fazilka has 41.7% of the population earning between Rs 5100 to 10,000 per month.

Table 4.7: Income-wise Distribution of respondents in Border Districts

Income (Rs)	Districts-wise numbers of villages						Total
	Pathankot	Gurdaspur	Amritsar	Tarn Taran	Ferozepur	Fazilka	
upto5000	30 (50.0)	32 (26.7)	23 (25.5)	28(31.1)	42 (46.6)	13 (21.6)	168 (32.9)
5100-10,000	21 (35.0)	35 (29.2)	34 (37.8)	10 (11.1)	28 (31.1)	25 (41.7)	153 (30.0)
11000-20,000	6 (10.0)	38 (31.6)	24 (26.7)	24 (26.7)	19 (21.1)	21 (35)	132 (25.8)
Above 20,000	3 (5.0)	15 (12.5)	9 (10)	28 (31.1)	1(1.1)	1 (1.70)	57 (11.2)
Total	**60 (100.0)**	**120 (100.0)**	**90 (100.0)**	**90 (100.0)**	**90 (100.0)**	**60 (100.0)**	**510(100.0)**

Source: Field Survey (Percentage in parentheses)

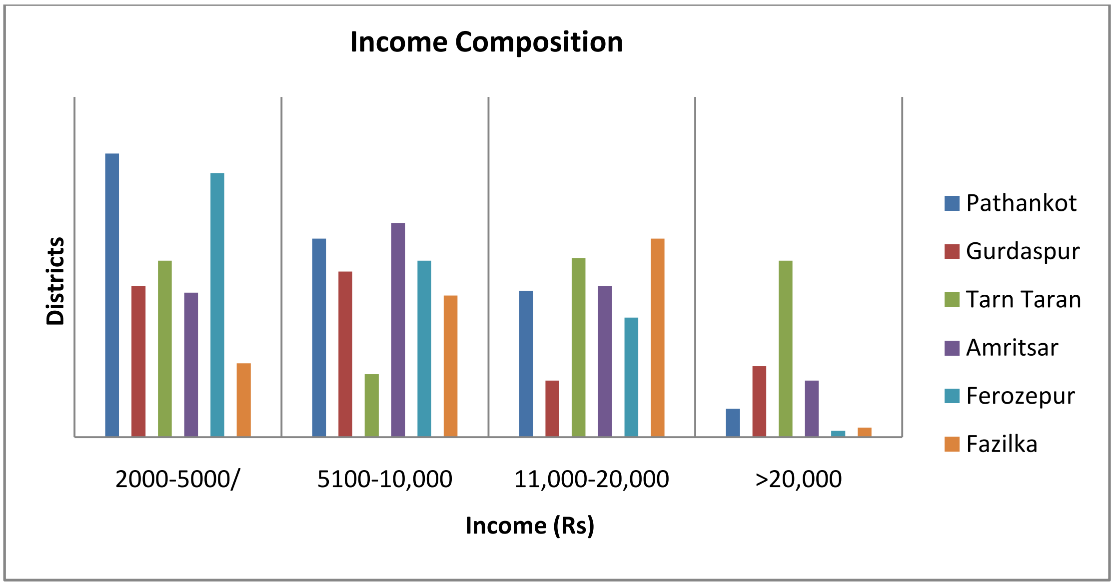


Fig.4.3: Income-wise Distribution of respondents in Border Districts

4.1.1.8 Size of Landholding

Those residents who practice agriculture have different sizes of landholdings and Table 4.8 below shows that on an average people have 1-4 acres of land (30.78%). District Tarn Taran has maximum (11.1%) number of people with bigger (11-20 acres) size of landholdings. District Pathankot has maximum (41.6%) number of marginal farmers (1-4 acres) and minimum in District Ferozepur (11.1%). Similarly, district Amritsar and Tarn Taran have more percentage of marginal farmers followed by small scale farmers with land size holding of 5-10 acres.

Table 4.8: Size of Landholding- Distribution of respondents in Border Districts

Size (in acres)	**Districts**						
	Pathankot	**Gurdaspur**	**Amritsar**	**Tarn Taran**	**Ferozepur**	**Fazilka**	**Total**
1-4	25 (41.6)	44 (36.6)	34 (37.8)	25 (27.8)	10 (11.1)	19 (31.6)	157 (30.78)
5-10	4 (6.6)	9 (7.5)	19 (21.1)	21 (23.3)	20 (22.2)	4 (6.7)	77 (15.1)
11-20	0	0	0 (0)	10 (11.1)	8 (8.9)	0	18 (3.5)
Above 20	0	0	0 (0)	0	2 (2.2)	0	2 (0.39)
Nil	31 (51.7)	67 (55.8)	37 (41.1)	34 (37.8)	50 (55.5)	37 (61.7)	256 (50.19)
Total	**60 (100.0)**	**120 (100.0)**	**90 (100.0)**	**90 (100.0)**	**90 (100.0)**	**60 (100.0)**	**510 (100.0)**

Source: Field Survey (Percentage in parentheses)

4.1.1.9 Source of Rural credit

As it is evident from the above data (Tables 4.1-4.8) that people in these border villages have varied level of basic facilities available, have variable income depending on their occupation and size of landholdings, so many times they have to take money on credit to meet their day-to-day or medical expenses and even for arranging family functions. Majority of people living in the study area take loan from banks (31.5%) and a little less preference is given to relatives (27.6%). Loan from moneylenders (14.9%) is the next option for the villagers. Only in district Fazilka people prefer taking loan from relatives 41.6% whereas in rest all the five districts preference is given to banks as shown in Table 4.9:

Table: 4.9: Rural Credit Source of respondents in Border Villages

District →	**Pathankot**	**Gurdaspur**	**Amritsar**	**Tarn Taran**	**Ferozepur**	**Fazilka**	**Total**
Source ↓							
Bank	17 (28.3)	40 (33.3)	25 (27.8)	39 (43.3)	27 (30.0)	13 (21.6)	161 (31.5)
Relatives	29 (48.3)	30 (25)	24 (26.6)	11 (12.2)	22 (24.4)	25 (41.6)	141 (27.6)
Moneylender	01 (1.7)	10 (8.3)	16 (17.8)	17 (18.9)	23 (25.5)	9 (15)	76 (14.9)
Others	0	14 (11.7)	16 (17.8)	11 (12.2)	8 (8.8)	6 (10)	55 (10.8)
Nil	13 (21.7)	26 (21.7)	9 (10)	12 (13.3)	10 (11.1)	7 (11.7)	77 (15.1)
Total	**60 (100.0)**	**120 (100.0)**	**90 (100.0)**	**90 (100.0)**	**90 (100.0)**	**60 (100.0)**	**510 (100.0)**

Source: Field survey (percentage in parentheses)

4.1.1.10 Health issues of respondents

All the respondents that were randomly selected during the survey had certain health issues but at the same time many of them were healthy also. The details are in Table 4.10 & Fig. 4.4, shows that overall, the people in all border districts as well as in individual districts are suffering from High Blood Pressure (35.1%) followed by Diabetes (21.6%). Very few suffer from Liver problems (5.7%). Healthy population has an overall percentage of 18.6% and District Fazilka has the highest % of people with no health issues (36.6%).

Table 4.10: Health Issues and Distribution of respondents in Border Districts of Punjab

Health Issues	**Districts**						**Total**
	Pathankot	**Gurdaspur**	**Amritsar**	**Tarn Taran**	**Ferozepur**	**Fazilka**	
Blood pressure	25 (41.7)	48 (40.0)	30 (33.3)	31(34.4)	27 (30)	18 (30)	179 (35.1)
Diabetes	10 (16.7)	35 (29.2)	19 (21.1)	18 (20.0)	19 (21.1)	9 (15)	110 (21.6)
Above Both	6 (10.0)	7 (5.8)	9 (10)	9 (10.0)	16 (17.7)	2 (3.3)	49 (9.61)
Liver issues	2 (3.3)	3 (2.5)	4 (4.4)	8 (8.8)	8 (8.8)	4 (6.7)	29 (5.7)
Knee problems	7 (11.6)	6 (5.0)	18 (20)	8 (8.8)	4 (4.4)	5 (8.3)	48 (9.4)
No health issue	10 (16.7)	21 (17.5)	10 (11.1)	16(17.7)	16 (17.7)	22 (36.6)	95 (18.6)
Total	60 (100.0)	120 (100.0)	90 (100.0)	90 (100.0)	90 (100.0)	60 (100.0)	510 (100.0)

Source: Field study (percentage in parentheses)

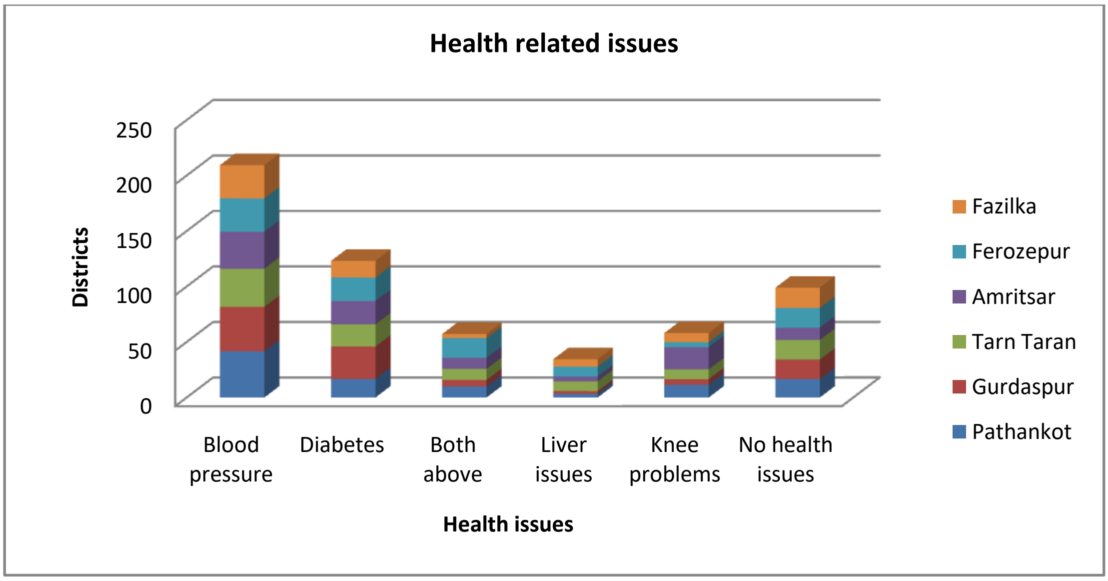


Fig. 4.4: Health related issues in border districts of Punjab

4.1.2 Environmental consciousness

The responses of the respondents to the questionnaire were tabulated (Table 4.11 & Fig. 4.5) and the data reveals that 87.6% of the villagers use pesticides, 65.8% of them practise stubble burning and only 23.7% people practise crop rotation. Majority of the people are not aware of the repercussions of dumping waste or throwing grey water in the open as 84.9% of the population is into this practice. A small percentage i.e. 6.4% were conscious of the importance of the soil and water quality check-up. District Amritsar and Fazilka have the maximum percentage of people practising pesticides application and it is least in the Gurdaspur district 61.7%. Stubble burning is highest in district Amritsar 100% and least in district Pathankot 18.3%. Similarly dumping of waste or grey water is highest in Amritsar and Ferozepur district (100%) and is least (61.6%) in District Gurdaspur. Maximum number of people who are aware of the importance of soil and water quality check are in district Gurdaspur and Tarn Taran (21.4%) and least awareness was found in district Fazilka 7.14%. The highest percentage (58.8%) of people who practise crop rotation is in Ferozepur district and the lowest value of 6.7% was from district Pathankot. Crop rotation in agriculture was also not much in practice in the districts of Majha region but Malwa belt was better and showed the maximum value in Ferozepur (58.8%) followed by District Fazilka (40%). The data from above table reflects that the respondents are not aware of the importance of environment, its conservation, and their long-term ill effects of their unsustainable practices.

Table 4.11: Awareness and Environmental consciousness amongst the respondents of selected border districts

S. No.	District	Total No. of Villages	Total No. of Respondents	No. of Respondents				
				Use of pesticides	Stubble burning	Dumping of waste/grey water	Soil/water quality check	Crop rotation
1.	Pathankot	4	60	53 (88.3)	11(18.3)	53 (88.3)	4 (14.3)	8 (6.7)
2.	Gurdaspur	8	120	74 (61.67)	77 (64.1)	74 (61.6)	6 (21.4)	15 (12.5)
3.	Amritsar	6	90	90 (100)	90 (100)	90 (100)	10 (11.1)	10 (11.1)
4.	Tarn Taran	6	90	90 (77.8)	50 (55.5)	78 (86.7)	6 (21.4)	11 (12.2)
5.	Ferozepur	6	90	80 (88.89)	73 (81.1)	78 (86.67)	5 (17.8)	53 (58.8)
6.	Fazilka	4	60	60 (100)	35 (58.3)	60 (100)	2 (7.14)	24 (40)
Total	**6**	**34**	**510**	**447 (87.6)**	**336 (65.8)**	**433 (84.9)**	**33 (6.4)**	**121 (23.7)**

Source: Field Survey (Percentage in parentheses)

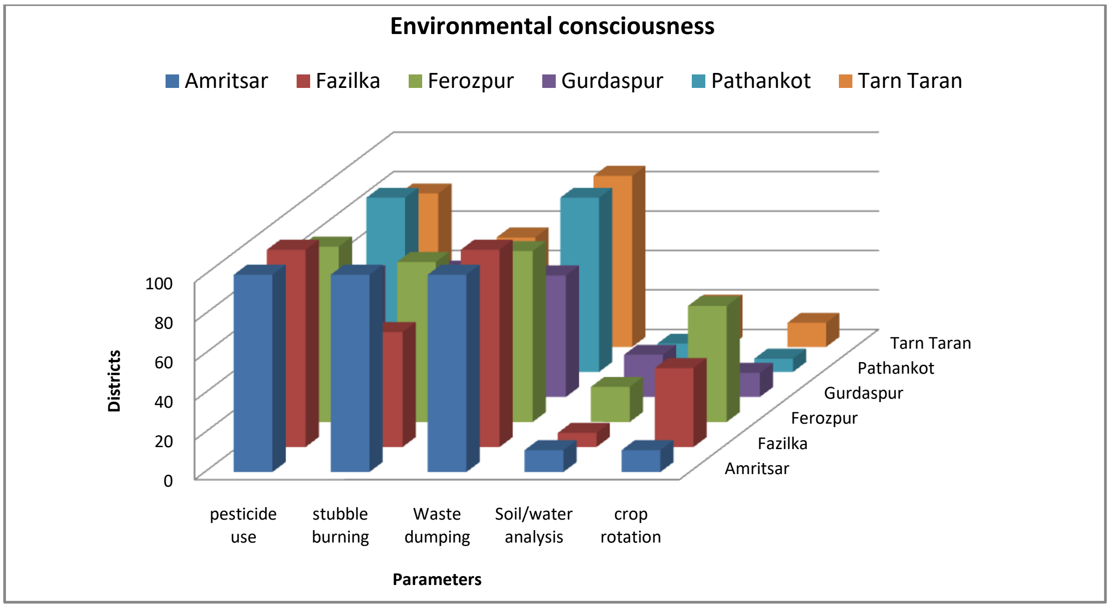


Fig.4.5: Environmental consciousness of respondents of Border villages

4.1.2.1 Awareness of use and safe use of Agrochemicals

As per the observations the overall percentage of people who use recommended dose of pesticides are 17.8% (Table 4.12 & Fig. 4.6). The highest percentage (21.9%) of people who use recommended dose of fertilizers /pesticide are in District Pathankot and lowest in District Amritsar (10.9%). Similarly, the overall number of people who use approximate dose is 60.6%. Maximum number of individuals who use approximate dose are in district Amritsar and Tarn Taran and minimum percentage is in Pathankot district. By and large a very few people (7.64%) have attended some training programmes regarding the use of pesticide and out of the total investigated population only 13.9% are apprised of the deleterious effects of the pesticides. The maximum number of people who are apprised of the deleterious effects of pesticides are from district Gurdaspur (30.9%) and least are from District Amritsar (7.04%). From the above table it is very evident that there is lack of awareness of the ill effects as well as usage of the fertilizers and agrochemicals.

Table 4.12: Awareness of dosage use and safety of pesticides

S. No.	District	No. of Respondents			
		Recommended dose	Approximate dose	Attended any training programme	Aware of any ill effects
1	Pathankot	20 (21.9)	32 (10.3)	5 (12.8)	12 (16.9)
2	Gurdaspur	18 (19.7)	50 (16.18)	12 (30.7)	22 (30.9)
3	Amritsar	10 (10.9)	63 (20.4)	5 (12.8)	5 (7.04)
4	Tarn Taran	16 (17.5)	60 (20.4)	8 (20.5)	12 (16.9)
5	Ferozepur	15 (16.5)	57 (18.4)	5 (12.8)	10 (14.1)
6	Fazilka	12 (13.18)	47 (15.2)	9 (23.1)	10 (14.1)
Total	**510**	**91 (17.8)**	**309 (60.6)**	**39 (7.64)**	**71 (13.9)**

Source: Field study (percentage in parentheses)

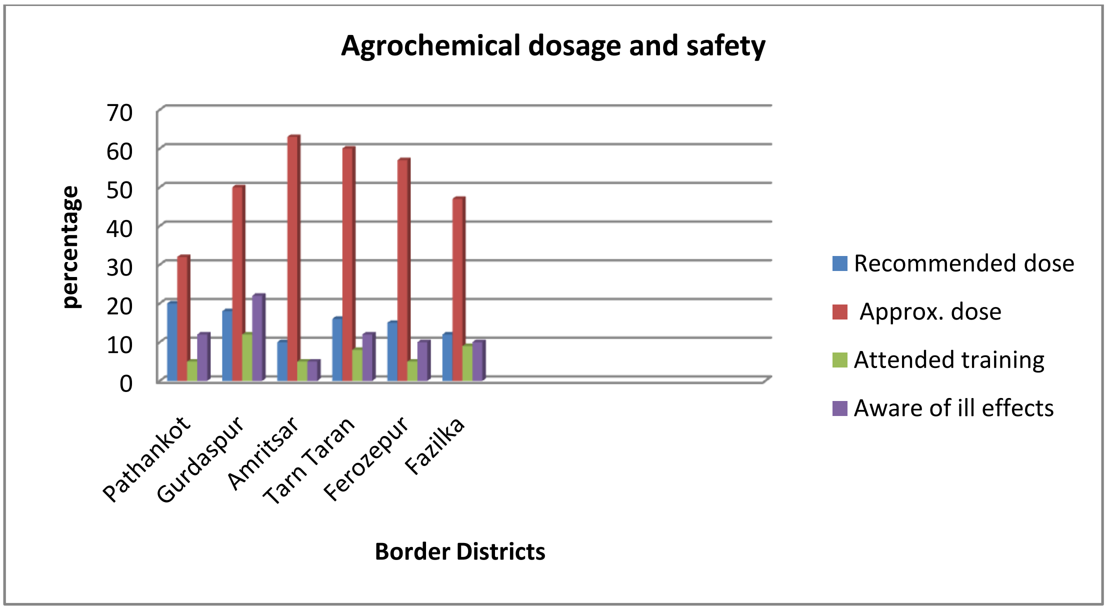


Fig. 4.6: Awareness of dosage use and safety of pesticides amongst the respondents of selected border villages

4.1.3 Relationship between education level and use of pesticides, fertilizers and agrochemicals and Environmental awareness

In the present study an attempt has been made to assess the relationship between level of education of the population and the prevalence of usage of fertilisers, pesticides and agrochemicals. From the Table 4.13 & Fig. 4.7, it is evident that level of education and usage of fertilizers/pesticides by the people in the present study area has a direct relation. 87.6% of the population use pesticides irrespective of their education level. Those who have no formal education are the highest users (45.8%) of pesticides and (43.2%) of fertilizers. 1.78% of the post-graduate use pesticides. Whereas 92.5% of the population use fertilizers out of which highest percentage is 43.2% are illiterate. The least usage of pesticides is by post graduate farmers (1.48%).

Table 4.13: Level of Education and usage of agrochemicals

S. No.	Education level	No. of Respondents	
		Use of pesticides	Use of fertilizers
1	Illiterate	205 (45.8)	204 (43.2)
3	Matric	115 (25.7)	148 (31.35)
4	10+2	97 (21.7)	95 (20.1)
5	Graduate	23 (5.14)	18 (3.81)
6	Post graduate	8 (1.78)	7 (1.48)
Total	**510**	**447 (87.6)**	**472 (92.5)**

Source: Field study (percentage in parentheses)

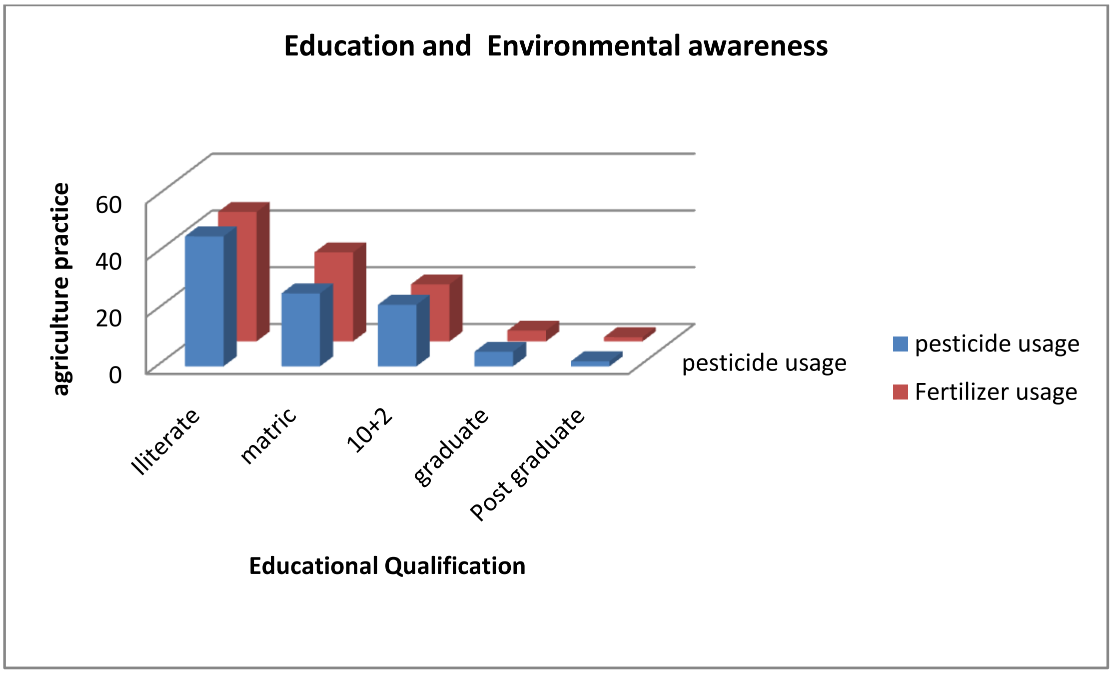


Fig. 4.7: Level of Education and usage of agrochemicals

Objective 2

4.2 Soil analysis

All the soil samples taken from agriculture fields of 34 villages located near in the border belt of Punjab in the Malwa and Mahja regions were analysed for different physical chemical parameters, heavy metal and metalloid contents. Descriptive statistical analysis was performed to determine the statistical significance of variation in different parameters of the soil samples. Pearson correlation analysis was done to estimate the possible relationship between various physical and chemical parameters and content of heavy metals present in the soil samples. An earnest effort was made to compare the results of various parameters analysed in the soil samples amongst the different districts.

4.2.1 Physico-chemical analysis

The soil samples from the agricultural fields of the chosen area were collected from thirty-four villages of all border blocks of the six border districts. The collection was done in the month of October from 2019 to 2021 and were analysed for various physico-chemical attributes i.e. pH, Electrical conductivity (EC), moisture content (MC), bulk density (BD), soil texture, soil organic carbon (OC), soil organic matter (SOM), potassium (K), total nitrogen (TN) and phosphorous (P). To understand the statistical significance of variations in these parameters, Pearsons Correlation analysis was done. The results of these parameters are summarized in Tables 4.14 & 4.15 and Figures 4.8 to 4.16. The bar values represent mean± SE (n=34). Site codes and other details are in Chapter 3 “Materials and Methods” (Table 3.1).

Table 4.14: Physico-chemical parameters (Mean± SE) analysed in soil samples collected from Border Villages of Punjab

site	pH	EC (µs/cm)	MC (%)	BD (g/cm^3)	SOM (%)	OC (%)	N (mg/kg)	K (mg/kg)	P (mg/kg)
ABK	7.033±0.203	75.430±1.37	4.35±0.0681	1.060±0.0503	0.602±0.00289	0.353±0.0296	70.4±14.2	253.7±14.30	19.467±0.467
ARNN	7.667±0.0333	68.330±3.93	15.46±0.145	0.916±0.0214	0.497±0.0251	0.293±0.024	74.93±8.36	232.60±12.30	17.767±0.524
AHM	6.900±0.0577	69.667±0.882	6.500±0.289	1.143±0.0318	0.623±0.00882	0.367±0.129	68.33±3.93	60.30±10.30	21.157±0.808
ABH	6.966±0.0882	65.00±1.15	14.700±0.153	1.052±0.0718	0.573±0.0319	0.333±0.0186	80.97±4.24	215.370±5.54	17.660±0.544
ABA	8.000±0.115	75.00±3.21	6.733±0.0667	0.905±0.0173	1.093±0.485	0.350±0.0208	75.43±1.37	253.70±14.30	12.510±0.656
ADK	7.733±0.0333	167.67±5.24	14.467±0.0882	1.143±0.0318	0.664±0.0303	0.3867±0.0176	74.93±8.36	227.90±13.40	21.157±0.808
ZARNW	9.000±1.15	163.00±2.08	24.900±0.231	1.100±0.115	0.791±0.0646	0.453±0.0145	15.33±1.34	111.30±18.10	11.71±0.159
ZDQ	7.800±0.231	125.00±2.89	13.500±0.577	1.283±0.0664	1.015±0.00144	0.593±0.0273	16.067±0.825	177.000±3.62	15.13±1.58
ZASF	8.500±0.577	106.00±2.31	12.85±0.184	1.16±0.0404	1.135±0.0645	0.63±0.0351	43.33±5.69	142.330±3.04	12.51±0.656
ZMJ	7.700±0.52	172.00±2.31	14.99±0.0577	1.143±0.0318	0.879±0.0176	0.51±0.0306	15.33±1.34	168.900±1.73	12.46±0.203
FJHC	7.000±0.153	127.00±12.3	6.840±0.58	1.100±0.173	0.515±0.009	0.303±0.047	75.43±1.37	232.60±12.30	11.410±0.657
FKRM	8.600±1.66	224.00±21.6	21.523±0.792	1.143±0.0318	0.603±0.0502	0.35±0.0416	74.93±8.36	227.90±13.40	16.900±0.346
FBKE	8.767±0.578	127.00±9.61	7.067±0.733	1.200±0.0577	0.680±0.0404	0.403±0.0463	59.30±5.71	158.700±33.3	11.507±0.402
FHZ	7.700±1.11	220.30±11.6	10.300±0.315	0.800±0.137	0.516±0.0606	0.303±0.0524	80.97±4.24	225.300±2.75	11.033±0.291
FMMH	8.000±0.814	240.00±52.4	18.23±0.596	0.99±0.0058	0.516±0.0338	0.307±0.024	42.60±6.48	266.700±16.80	4.233±0.644
FROH	7.500±1.6	240.00±25.6	9.063±0.54	1.05±0.411	0.430±0.115	0.25±0.0265	75.43±1.37	227.90±13.40	12.467±0.203
GPK	7.200±0.173	167.67±5.24	13.84±0.784	0.93±0.0115	1.082±0.0393	0.63±0.0231	74.43±2.3	215.370±5.54	25.877±0.768
GJKD	7.567±0.12	220.30±11.6	19.367±0.954	0.88±0.0153	0.905±0.0321	0.526±0.0186	70.40±14.2	253.700±14.30	16.840±1.23
GDTP	6.733±0.0667	186.00±1.85	19.97±1.08	0.877±0.0233	0.963±0.0359	0.56±0.0208	80.97±4.24	227.90±13.40	17.660±0.544
GGK	7.30±0.0577	238.07±1.1	18.707±0.82	0.9433±0.0176	1.221±0.0595	0.71±0.0346	74.93±8.36	216.33±7.69	11.717±0.159
GBQC	7.166±0.0882	238.07±1.1	8.68±0.328	0.886±0.0285	0.980±0.0398	0.57±0.0231	53.30±2.34	136.00±4.16	22.960±0.9
GND	6.766±0.0882	185.33±3.76	19.54±0.53	0.79±0.0153	0.733±0.0347	0.4267±0.203	76.70±6.32	232.60±12.30	25.110±0.405
GDT	7.066±0.0882	263.33±6.12	16.70±0.396	1.0467±0.0203	0.607±0.025	0.353±0.0145	77.23±4.15	115.07±4.06	24.130±1.84
GBLP	7.666±0.0882	356.00±3.79	15.45±0.662	0.7933±0.0384	0.854±0.0412	0.496±0.024	95.07±4.88	109.87±3.09	12.840±0.319
PKC	8.10±0.0577	162.33±1.86	11.547±0.525	1.117±0.0549	0.671±0.0199	0.390±0.0115	93.87±5.38	232.60±12.30	13.107±0.315
PDH	8.20±0.115	120.00±1.15	12.16±0.156	1.213±0.0233	0.630±0.0321	0.367±0.0186	41.10±0.723	253.700±14.30	11.507±0.402
PPP	8.233±0.0667	124.33±2.85	12.827±0.317	1.18±0.0351	0.642±0.0319	0.373±0.0186	46.43±5.43	134.20±4.580	13.167±0.186
PDTL	8.133±0.0882	140.33±1.45	17.293±0.499	1.1±0.0153	0.699±0.015	0.407±0.00882	47.10±5.01	127.53±1.58	13.107±0.315
TMKP	8.033±0.0882	238.07±1.1	8.37±0.0814	1.17±0.0379	0.688±0.0176	0.406±0.0549	53.3±23.4	190.83±7.92	15.130±1.58
TBJ	7.40±0.0577	263.33±6.12	12.80±0.379	1.183±0.0088	1.033±0.0326	0.600±0.0171	41.53±1.88	232.60±12.30	14.367±0.296
TWTS	8.266±0.0882	247.07±1.7	12.50±0.346	1.07±0.0551	0.602±0.00617	0.350±0.03	44.00±1.76	227.90±13.40	12.467±0.203
TKL	8.10±0.0577	166.07±1.16	7.81±0.259	1.16±0.0115	0.655±0.0245	0.380±0.0289	93.87±5.38	60.30±10.30	19.400±0.907
TMK	7.00±0.0882	268.67±2.03	10.70±0.0814	0.97±0.0379	0.655±0.0176	0.380±0.0549	74.93±8.36	212.90±7.92	18.467±1.58
TDL	7.067±0.12	186.00±1.85	8.486±0.0784	0.53±0.105	0.566±0.0261	0.323±0.0133	53.30±2.34	36.57±3.33	13.50±0.608

Table 4.15: Summary of overall range of physico-chemical parameters (Mean± SE) of soil samples collected from the Border villages

Parameter/units	Limit	Range	Mean± SE
pH	6.50-8.50	6.9-9.0	7.673±0.103
Electrical conductivity (µS/cm)	4500.00	65-268.67	174.33±21.23
Moisture content (%)	NA	4.35-24.900	13.183±0.848
Bulk density (g/cm^3)	NA	0.79-1.283	1.043±0.0443
Organic carbon (%)	NA	0.25-0.71	0.424±0.0198
Soil organic matter (%)	3.40	0.43-1.221	0.7447±0.0362
Available phosphorus (mg/kg)	NA	4.233-25.877	15.600±0.818
Total nitrogen (mg/kg)	NA	15.3-95.07	62.813±7.154
Potassium (mg/kg)	0-450.00	36.57-266.7	188.18±20.882
Sand (%)	NA	20.89-50.22	31.6933 ±7.235
Silt (%)	NA	14.1-37.81	22.08 ±7.662
Clay (%)	NA	16.53-67.28	47.315±12.316

4.2.1.1 pH and EC

All the soil samples collected from the study area showed pH in the alkaline range (Fig.4.8). The value of pH in the samples varied from 9.0 to 6.733 at sites ZARNW and GDTL respectively. The mean value of pH was found to be 7.48. The values obtained from all the selected sites was within the range of 6.5 to 8.5 well within the limits of the Indian standards of soil quality.

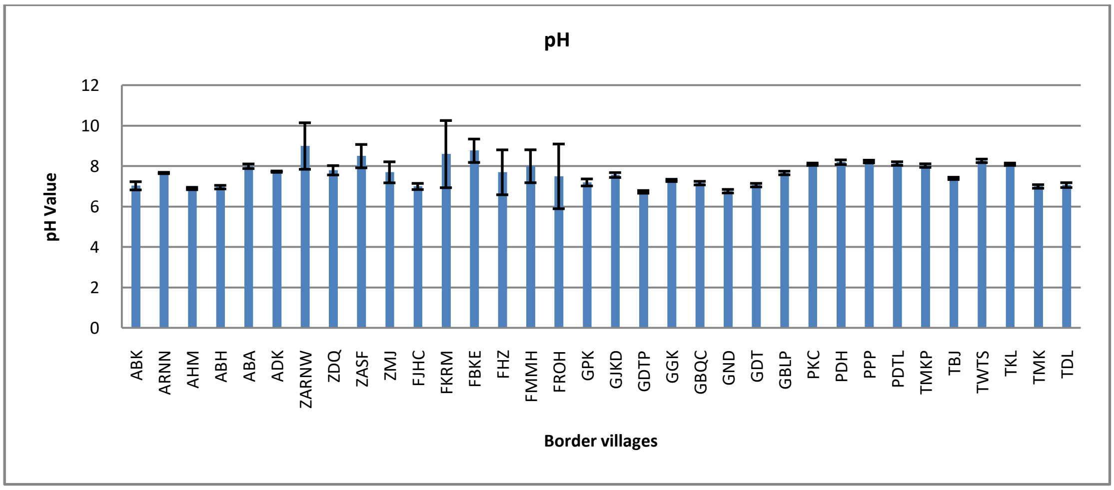


Fig. 4.8: pH of the soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 “Materials and Methods” (Table 3.2).

4.2.1.2 Total Dissolved Solids (TDS)

For the soil samples, the conductivity ranged from 65µS/cm to 268.67µS/cm at ABH and TMK sites respectively. The mean value of EC of soil samples was 174 µS/cm. Table 4.15 & Fig. 4.9 shows all the samples have EC well within the standard limits.

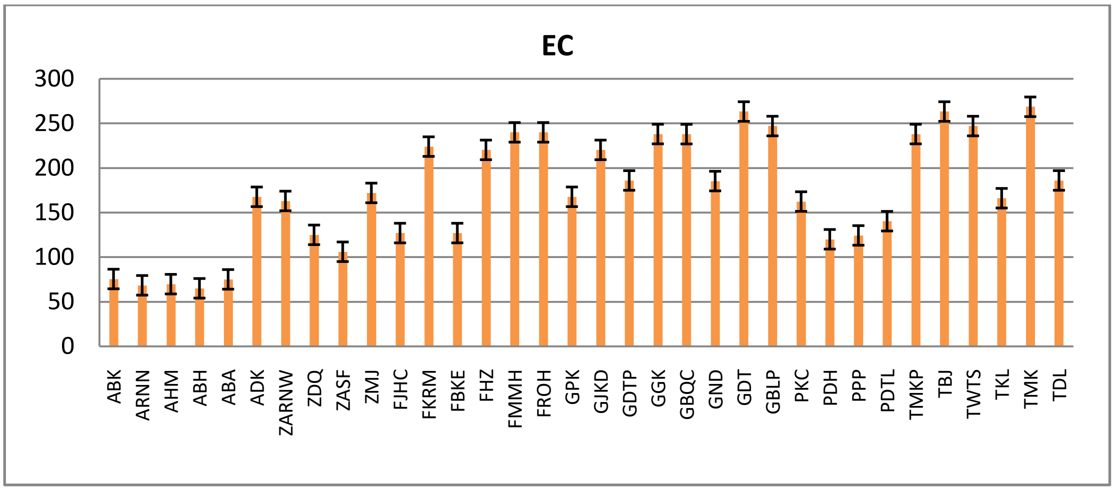


Fig. 4.9: EC of the soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 "Materials and Methods" (Table 3.2).

4.2.1.3 Bulk Density (BD)

The bulk density (Fig. 4.10) of the soil samples analysed revealed minimum value of 0.79 at site GND and maximum was 1.283 at site ZDQ with a mean value of 1.043 g/cm^3.

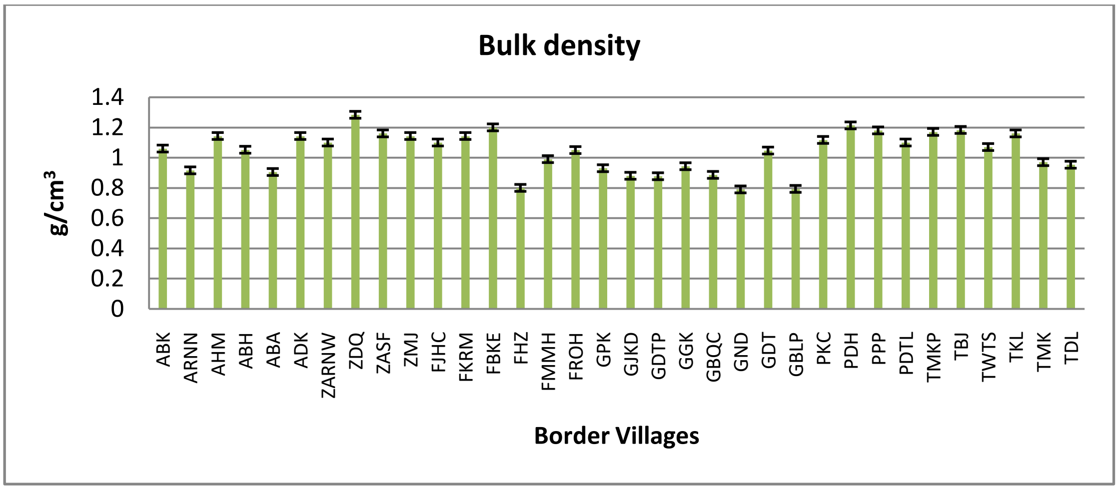


Fig. 4.10: BD of the soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 "Materials and Methods" (Table 3.2).

4.2.1.4 Moisture Content (MC)

Moisture content (Fig.4.11) in soil samples taken from border villages showed a range of 24.9% at site ZARNW to 4.35% at site ABK and a mean value of 13.183%.

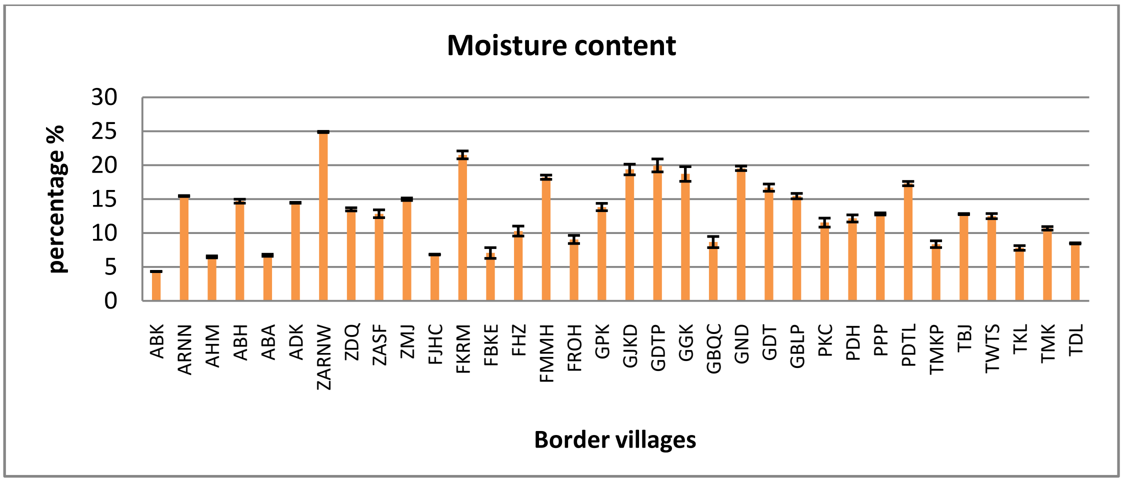


Fig. 4.11: MC of the soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 “Materials and Methods” (Table 3.2).

4.2.1.5 Soil Organic Matter (SOM)

The value of soil organic matter varied from 0.43% at site FROH to 1.221% at GGK site (Fig.4.12) and a mean of value of 0.745 %. They are to some extent indicators of soil health or soil agroecosystem. Similarly, the soil organic carbon (Fig.4.13) is highest at site GGK 0.71% and lowest at FROH 0.25%. The mean value of OC is 0.425%.

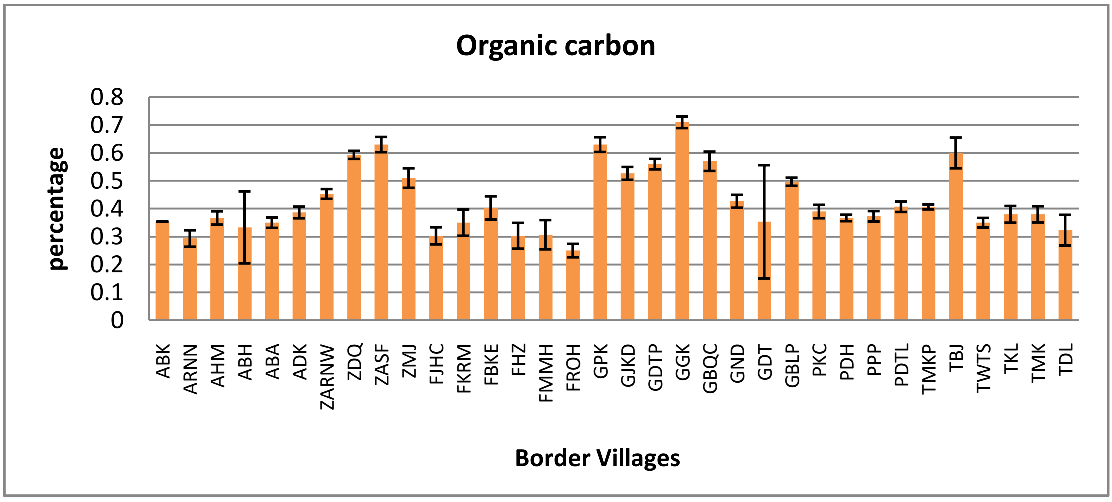


Fig. 4.12: OC of the soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 “Materials and Methods” (Table 3.2).

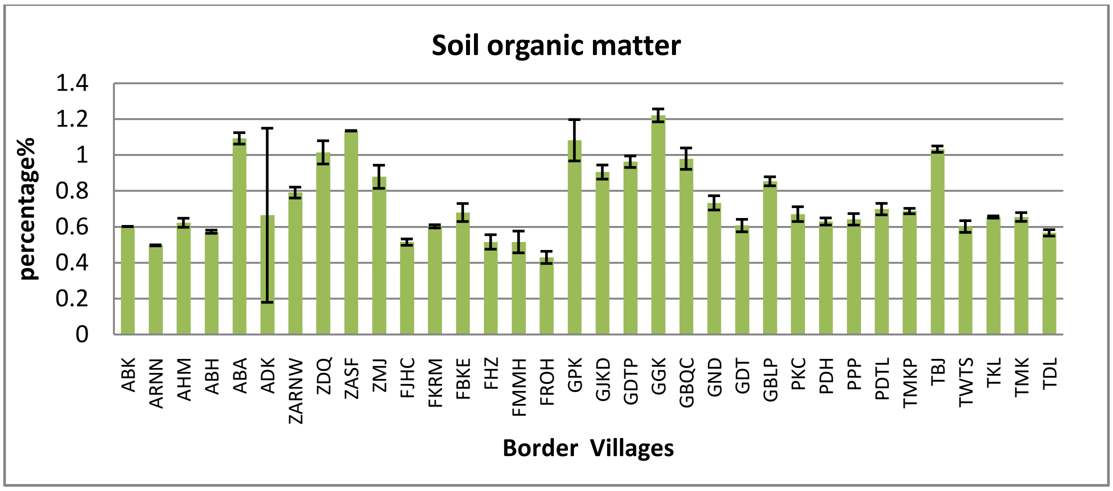


Fig. 4.13: SOM of the soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 “Materials and Methods” (Table 3.2).

4.2.1.6 Potassium content

The content of Potassium (Fig.4.14) in the soil samples of study area were in the range of 60.3 mg/kg at site AHM to 275.4mg/kg at site FROH. The mean value of the same has been found to be 187.799 mg/kg in the soil samples.

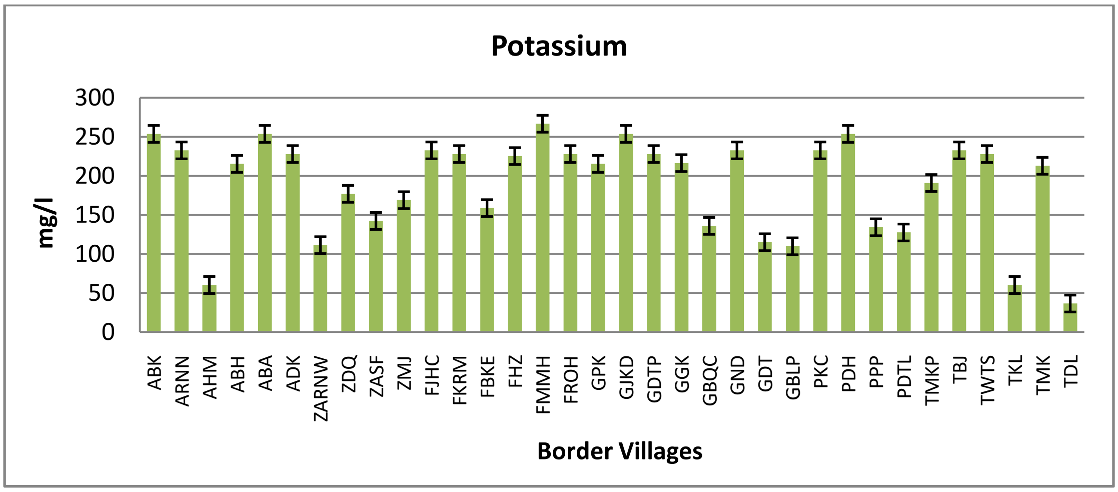


Fig. 4.14: K content of the soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 “Materials and Methods” (Table 3.2).

4.2.1.7 Nitrogen content

The total nitrogen content (Fig. 4.15) in soil samples collected during the current survey ranged from 15.33 at ZMJ, ZARNW to 95.07 mg/kg at site GBLP. The mean value was found to be 62.813 mg/kg.

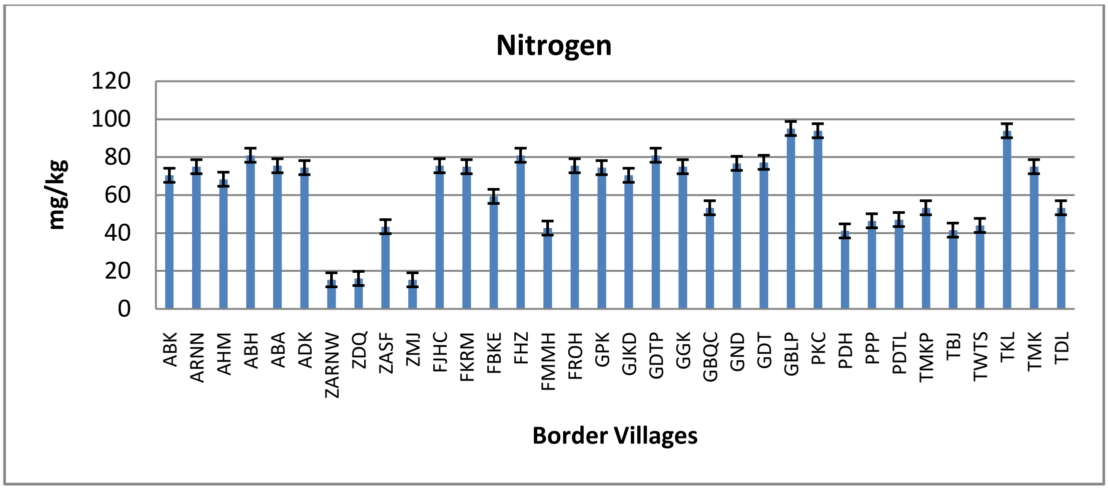


Fig. 4.15: N content of the soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 "Materials and Methods" (Table 3.2).

4.2.1.8 Phosphorus content

The results of phosphorus content (Fig.4.16) in the soil samples taken from the study area varied from 4.233 to 25.877 mg/kg at site FMMH and GPK site respectively. The mean value of phosphorous content in the border districts of Punjab was found to be 13.659 mg/kg.

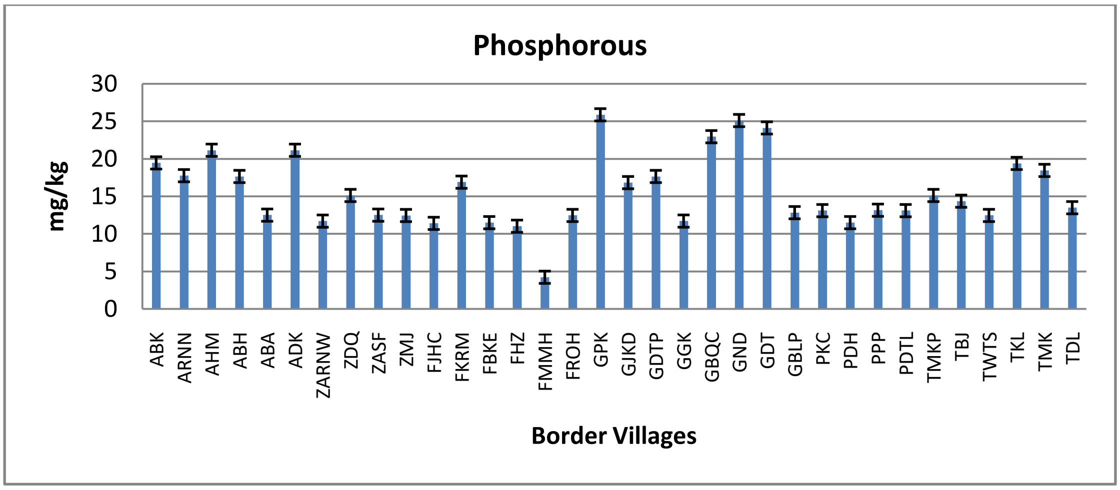


Fig. 4.16: P content of the soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 "Materials and Methods" (Table 3.2).

4.2.1.9 Soil texture

The results of soil composition analysis in the collected samples revealed that the proportion of clay dominates followed by the percentage of sand and silt respectively. The soil samples were of different types ranging from sandy loam to clayey loam.

Highest percentage of clay was is in the soils of district Gurdaspur (60.37%) and the minimum is in the district Amritsar (16.53%) as shown in table 4.16 & Fig. 4.17

Table 4.16: Soil composition in the border districts of Punjab

District	Sand %	Silt %	Clay %
Pathankot	27.79	37.81	39.91
Gurdaspur	20.89	17.59	60.37
Amritsar	50.22	32.95	16.53
Tarn Taran	28.11	14.1	60.28
Ferozepur	30.46	14.36	55.18
Fazilka	32.69	15.67	51.62

Source: Field Survey

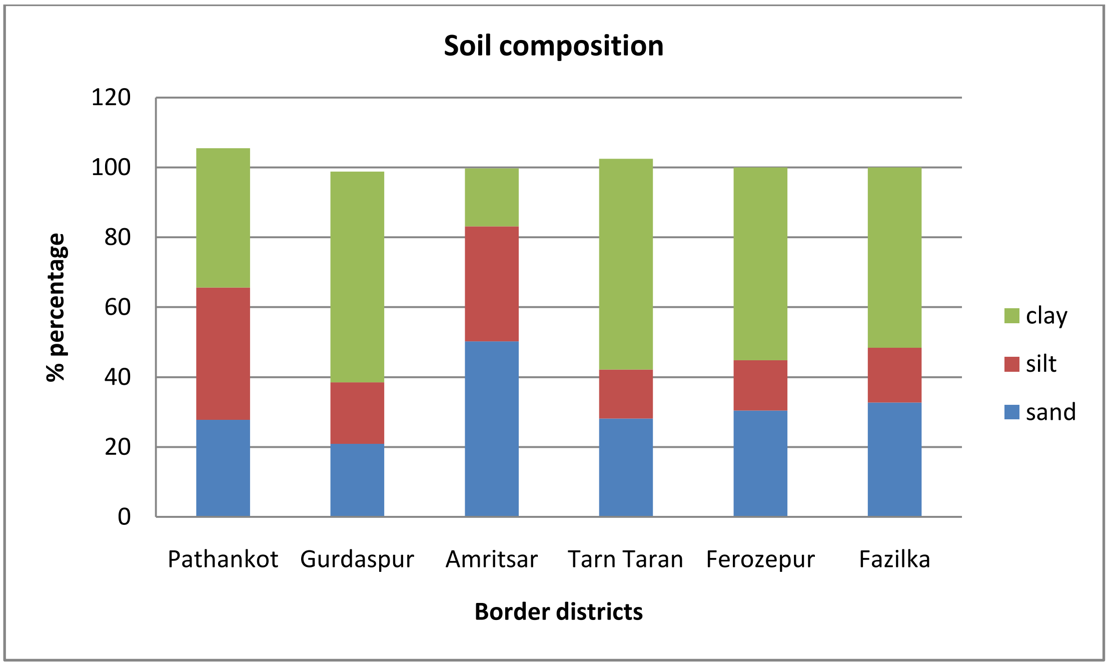


Fig. 4.17: Composition of the soil samples collected from border districts of Punjab

#Sample codes are described in detail in chapter 3 “Materials and Methods” (Table 3.2).

The following Fig. 4.18 depicts the results of all the physico-chemical parameters of soil samples analysed in the current investigation. It is very much clear from the graph that pH is not very variable in all the selected districts. District Amritsar showed the maximum content of nitrogen, phosphorus, potassium and also the amount of sand and silt in the soil. Electrical conductivity was highest in district Tarn Taran and clay content in soil was highest in district Gurdaspur.

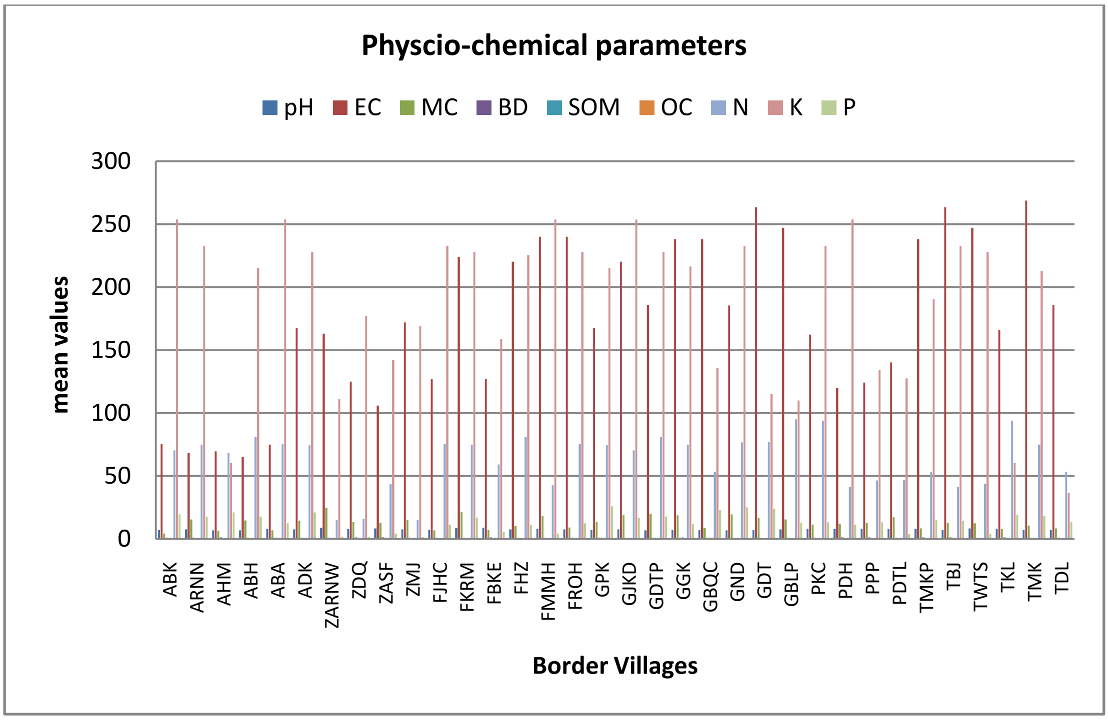


Fig. 4.18: Physico-chemical parameters analysis of the soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 "Materials and Methods" (Table 3.2).

4.2.2 Heavy metal analysis of soil samples

All soil samples gathered from the various sites of study area revealed the presence of various heavy elements. The results were compared with the permissible limits of BIS/ WHO. It was found that majority of the heavy metals were within the permissible limits but some of them exceeded these limits. The soil samples were analysed for Uranium (U), Selenium (Se), Cadmium (Cd), Nickel (Ni), Chromium (Cr), Arsenic (As), Lead (Pb), and Mercury (Hg). The details of heavy metal concentrations obtained from different sites are presented in Table 4.17.

Table 4.17: Heavy metal (Mean ± S.E.) analysis in the soil samples collected from border villages of Punjab

Site	Selenium	Cadmium	Arsenic	Lead	Chromium	Nickel	Uranium	Mercury
PKC	0.0433±0.0001	0.006±0.0033	0.073±0.008	ND	0.046±0.008	0.016±0.005	0.0733±0.008	ND
PDH	0.0133±0.008	0.006±0.0033	0.066±0.0033	ND	0.046±0.012	0.01±0	0.0733±0.008	ND
PPP	0.050±0.0115	0.016±0.0033	0.034±0.0227	ND	0.036±0.007	0.016±0.005	0.0333±0.007	ND
PDTL	0.010±0.0007	0.003±0.003	0.006±0.0033	ND	0.013±0.008	0.013±0.0033	0.0667±0.0033	ND
GPK	0.016±0.007	0.003±0.003	0.0566±0.003	ND	0.0267±0.0067	0.006±0.0053	0.04333±0.006	0.003±0.0008
GJKD	0.030±0.006	ND	0.060±0.01	ND	0.060±0.01	ND	0.03667±0.007	0.000667±0.0033
GDT	0.056±0.008	0.006±0.0033	0.060±0.005	0.0167±0.0033	0.043±0.006	ND	0.0733±0.0145	0.000667±0.0033
GGK	0.043±0.008	0.010±0	0.030±0.005	0.0167±0033	0.053±0.008	0.013±0.003	0.01667±0.0033	0.002±0.00088
GBQC	0.056±0.008	0.003±0.003	0.080±0.005	ND	0.043±0.008	0.016±0.005	0.0133±0.003	0.001±0.00058
GND	0.043±0.008	ND	0.040±0.01	ND	0.056±0.008	0.016±0.005	0.0133±0.003	0.0003±0.0003
GDT	0.010±0.006	0.013±0.0033	0.033±0.007	ND	0.043±0.008	0.013±0.003	0.016±0.05	0.0016±0.000
GBLP	0.013±0.003	0.013±0.0033	0.040±0.006	ND	0.016±0.05	0.02±0.003	0.01067±0.005	ND
ABK	0.0270±0.030	0.010±0.0057	0.046±0.008	0.013±0.008	0.046±0.008	0.086±0.012	0.01667±0.0033	ND
ARNN	ND	0.013±0.0067	0.060±0.005	0.016±0.003	0.0100±0.005	0.0733±0.0145	0.07333±0.0145	ND
AHM	ND	0.013±0.0067	0.033±0.228	0.010±0.0	0.053±0.008	0.080±0.005	0.013±0.008	ND
ABH	ND	ND	0.070±0.0231	0.02±0.003	0.043±0.006	0.073±0.003	0.01333±0.003	ND
ABA	0.05±0.008	ND	0.046±0.0080.007	0.020±0.005	0.0867±0.0448	0.043±0.0145	0.01067±0.005	ND
ADK	0.04±0.012	ND	0.033±0.0077	0.0.013±0.008	ND	0.050±0.005	0.0667±0.0033	ND
TMKP	0.040±0.012	0.036±0.0088	0.043±0.012	ND	0.056±0.003	ND	0.01067±0.005	0.003±0.0012
TBJ	0.043±0.012	0.013±0.020	0.036±0.003	ND	0.067±0.003	0.003±0.003	0.04333±0.0001	0.003±0.0012
TWTS	0.056±0.008	0.0169±0.088	0.046±0.008	ND	0.086±0.0448	0.07±0.003	0.0333±0.007	0.002±0.0003
TKL	0.056±0.008	0.013±0.0088	0.080±0.0115	ND	0.010±0.005	0.006±0.003	0.0267±0.0067	0.001±0.0003
TMK	0.043±0.003	0.016±0.0067	0.013±0.003	ND	0.030±0.005	0.013±0.003	0.0267±0.0067	0.002±0.0012
TDL	0.050±0.0057	0.020±0.0057	0.020±0.0115	ND	0.006±0.003	0.006±0.003	0.03667±0.007	0.001±0.0003
FJHC	0.013±0.003	ND	0.067±0.003	0.016±0.003	ND	0.066±0.012	0.03667±0.007	ND
FKRM	0.056±0.008	0.006±0.003	0.036±0.003	0.010±0.0	ND	0.076±0.0233	0.0667±0.0033	ND
FBKE	0.0106±0.005	0.010±0.0057	0.040±0.006	0.01±0.003	ND	0.010±0.005	0.07667±0.0233	ND
FHZ	0.0103±0.005	ND	0.073±0.008	0.013±0.003	ND	0.013±0.008	0.06±0.012	ND
FMMH	0.056±0.008	0.016±0.0033	0.041±0.008	0.0166±0.003	ND	0.013±0.0053	0.0566±0.008	ND
FROH	ND	0.006±0.0033	0.040±0.006	0.016±0.003	ND	0.006±0.0053	0.041±0.011	ND
ZARNW	0.027±0.030	0.003±0.003	0.076±0.007	ND	0.020±0.0057	0.040±0.0115	0.013±0.003	ND
ZDQ	0.056±0.008	0.006±0.003	0.046±0.008	ND	0.04±0.006	0.030±0.005	0.04±0.006	ND
ZASF	0.010±0.000	ND	0.070±0.0057	ND	0.050±0.0115	0.020±0.0115	0.03667±0.007	ND
ZMJ	0.027±0.030	0.010±0.0057	0.053±0.008	ND	0.040±0.006	0.016±0.0067	0.0467±0.008	ND

Out of the total samples analysed for heavy metals, it was found that selenium was not detected in 11.76%, cadmium was not detected in 23.52%. Similarly lead, chromium, nickel and mercury were not detected in 58.8%, 20.58%, 11.76% and 61.76% respectively and had values within the permissible limit. The range and mean values of these heavy metals in soil samples are shown below (Table 4.18).

Table 4.18: Summary of overall range of Heavy metal content in soil samples of border villages of Punjab

Heavy metal content in 34 sites	Limit (mg/kg)	Range	Mean± SE	No. samples (Not detected, ND)	No. samples above limit
Selenium	0.2	0.01-0.056	0.031±0.005	4	-
Cadmium	0.02	0.003-0.02	0.011±0.004	8	-
Arsenic	2.0	0.006-0.08	0.0486±0.043	-	-
Lead	2.0	0.01-0.02	0.006±0.080	20	-
Chromium	1.30	0.006-0.086	0.033±0.007	7	-
Nickel	10	0.003-0.086	0.027±0.030	3	-
Uranium	1-10	0.003-0.086	0.027±0.030	-	-
Mercury	0.03-2.0	0.0003-0.003	0.0007±0.0002	21	-

District-wise it has been found that maximum mean values of majority of the heavy metals were in Tarn Taran followed by Amritsar. From the table 4.19 and figures 4.19, it is evident that the mean values of Lead and nickel are highest in the District Amritsar. It was observed that uranium content is highest in the soils of district Pathankot. In district Tarn Taran, heavy metals selenium, cadmium, chromium and mercury have the highest mean value. But all these values are well within the permissible limits.

Table 4.19: District-wise mean values of heavy metals in the soil samples collected from the Border Villages of Punjab

Site	Selenium	Cadmium	Arsenic	Lead	Chromium	Nickel	Uranium	Mercury
Pathankot	0.035	0.008	0.045	ND	0.036	0.014	**0.061**	ND
Gurdaspur	0.034	0.006	0.049	0.004	**0.043**	0.011	0.027	0.001
Amritsar	0.019	0.007	0.048	**0.015**	0.039	**0.067**	0.032	ND
Tarn Taran	**0.048**	**0.019**	0.039	ND	**0.043**	0.016	0.029	**0.002**
Ferozepur	0.024	0.006	0.049	0.013	ND	0.031	0.056	ND
Fazilka	0.03	0.005	**0.062**	ND	0.037	0.026	0.034	ND

#Bold values are the highest values obtained.

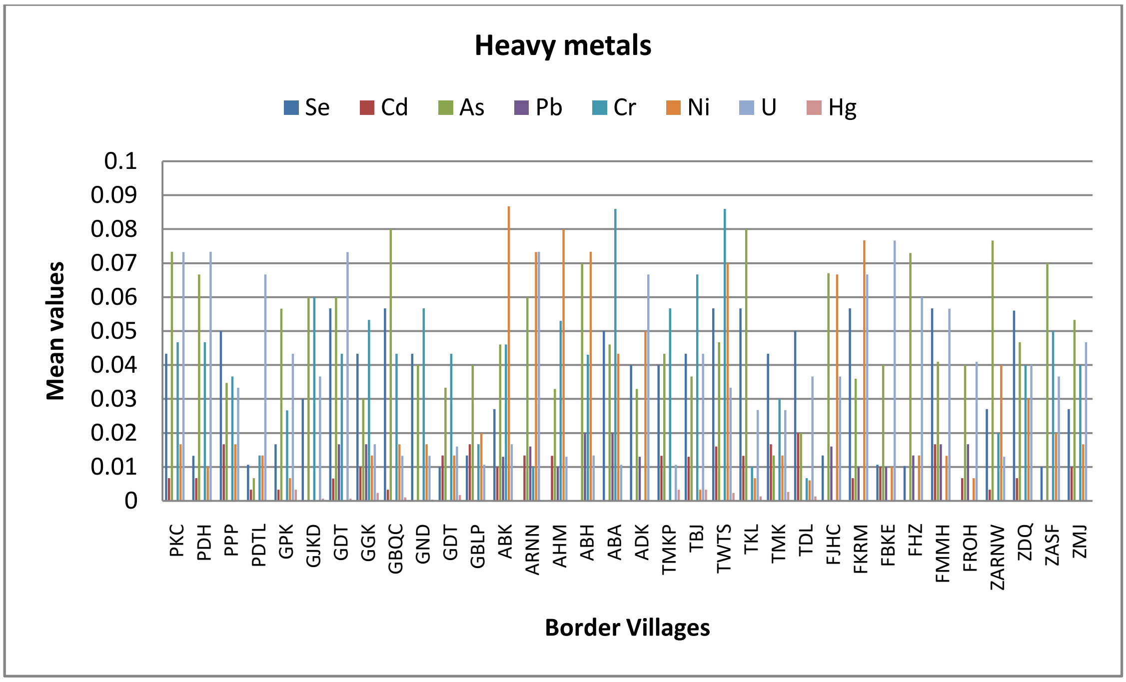


Fig. 4.19: Heavy metal analysis of soil samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 “Materials and Methods” (Table 3.2).

4.2.3 Pearson correlation analysis: physico-chemical parameters and heavy metal content of soil samples

In further studies, relationships between different physical chemical properties, assessment of heavy metal contents in soil samples were estimated by calculating Pearson correlation coefficients. The correlation matrices, prepared by performing correlation analysis in Mini Tab 14 software are presented in Table 4.20 and 4.21.

Table 4.20: Pearson correlation matrix of various physico-chemical parameters of soil samples collected from the Border Villages of Punjab

	pH	**EC**	**MC**	**BD**	**SOM**	**OC**	**N**	**K**
pH	1							
EC	-0.074	1						
MC	0.165	0.276	1					
BD	0.464*	-0.280	-0.202	1				
SOM	-0.011	0.049	0.202	-0.106	1			
OC	-0.063	0.172	0.303	-0.038	0.916*	1		
N	-0.396	0.052	-0.171	0.486*	-0.197	-0.242	1	
K	-0.079	0.047	0.123	-0.173	0.010	-0.054	0.142	1
P	-0.627	0.067	-0.129	-0.372	-0.069	-0.051	0.663*	0.046

*Significant at $p<0.05$ value

The table 4.20 shows that there is significant correlation between organic carbon and soil organic matter (SOM-OC r=0.916). There is a positive correlation between pH, bulk density (r=0.464), (BD-N r=0.486) and nitrogen and phosphorous (r=0.663) content of the soil and the values are significant at p>0.05.

Table 4.21: Pearson correlation matrix of heavy metals in the different soil samples collected from the Border Villages of Punjab

Se	**Cd**	**As**	**Pb**	**Cr**	**Ni**	**U**	**Hg**
Cd	0.227						
As	-0.077	-0.44					
Pb	-0.19	-0.235	0.037				
Cr	0.236	-0.035	0.05	-0.224			
Ni	-0.183	-0.095	0.056	0.431*	0.018		
U	-0.048	-0.08	0.02	0.133	-0.437	-0.12	
Hg	0.276	0.345*	-0.214	-0.343	0.341*	-0.345	-0.267

*Significant at $p<0.05$ value

Pearson correlation matrix of the heavy metals present in the soil samples was prepared (Table 4.21). A positive correlation was found between As-Hg (r=0.345), Cr-Ni (r=0.431), Ni-Hg (r=0.341) significant at p<0.05 value. Some negative correlations were observed between other heavy metals but they were not significant at p<0.01 or 0.05 value.

The quality of ground water and municipal water was carried out by analysing the physico-chemical parameters i.e. electrical conductivity (EC), Total dissolved solids (TDS), alkalinity, total hardness (TH), chloride, sulphate and magnesium ions, to study the suitability for agricultural and domestic purposes respectively. Analysis for heavy metal like selenium, arsenic, cadmium, chromium, lead, nickel, iron and uranium was also carried out.

4.3 Physico-chemical analysis of water samples

The results of physico-chemical analysis of 34 samples of ground and municipal water samples are given in table 4.22 & 4.23 and fig. 4.21 & 4.22, respectively and the data was subjected to descriptive statistical analysis and Pearson correlation matrix. We evaluated the parameters against the drinking water standards outlined by the Bureau of Indian Standards (BIS). The table 4.24 displays the percentage of samples exceeding the acceptable and preferred limits.

Table 4.22: Physico-chemical parameters (Mean± SE) analysed in ground water (GW) samples collected from the Border villages of Punjab

site	pH	EC (µS/cm)	TDS (mg/l)	Fluoride (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Sulphate (mg/l)	Magnesium (mg/l)
ABK	7.333±0.0333	190.0±0.577	277.33±0.882	0.4667±0.0333	11.533±0.581	2.733±0.233	455.33±1.2	354.0±1.15	69.433±0.782	13.487±0.452
ARNN	6.90±0.0577	164.67±0.882	287.67±1.45	0.3667±0.0333	11.167±0.328	1.233±0.145	511.67±0.882	353.67±2.03	80.2±1.17	25.303±0.602
AHM	6.70±0.0577	428.67±2.96	314.33±1.45	0.6±0.0577	31.933±0.636	1.067±0.233	554.33±2.03	303.33±1.76	78.093±0.57	30.47±0.45
ABH	6.767±0.0882	152.0±6.11	370.67±5.55	1.567±0.0882	32.903±0.589	1.307±0.471	551.0±1.53	354.0±1.73	65.65±1.26	16.923±0.272
ABA	6.80±0.0577	483.33±4.48	159.33±1.76	0.467±0.0882	12.443±0.507	1.667±0.203	301.67±0.882	252.0±1.15	78.613±0.491	14.44±0.295
ADK	6.733±0.0333	172.33±1.45	377.67±1.2	0.1667±0.033	22.353±0.615	1.2±0.208	352.0±1.15	207.33±3.71	75.76±1.48	16.417±0.377
ZARNW	7.90±0.0577	555.33±5.67	239.0±3.0	0.5867±0.0133	11.40±0.404	2.5667±0.0667	303.0±3.33	207.33±3.71	218.54±1.91	23.637±0.177
ZDQ	6.767±0.0667	133.0±1.15	413.0±4.04	1.11±0.0723	38.967±0.633	2.395±0.	249.33±3.53	296.0±3.61	167.17±0.964	80.693±0.625
ZASF	7.00±0.0577	499.0±11.4	221.0±5.57	1.467±0.0667	19.267±0.913	7.367±0.186	352.33±0.882	249.33±2.33	221.85±1.89	37.517±0.152
ZMJ	6.70±0.0577	133.0±1.73	406.67±3.18	0.01±0.005	20.833±0.033	7.063±0.252	335.0±8.39	381.0±8.5	144.78±0.685	39.333±0.693
FJHC	7.10±0.608	859.67±6.33	341.67±4.33	0.8±0.0115	21.837±0.506	2.633±0.0667	453.67±1.86	252.33±0.882	199.49±6.46	19.427±0.678
FKRM	8.167±0.0882	723.0±1.53	338.0±1.53	0.3±0.0577	21.29±0.554	0.50±0.0577	305.33±2.03	103.0±1.53	232.87±5.03	23.767±0.53
FBKE	8.00±0.0577	315.0±3.2	150.0±0	1.1667±0.033	21.21±0.235	21.717±0.873	351.67±0.882	206.67±3.33	205.19±3.72	16.843±0.426
FHZ	7.33±0.0667	106.0±5.57	375.67±4.98	0.6±0.0577	11.613±0.304	1.233±0.145	210.0±5.77	152.0±1.15	210.42±6.61	17.103±0.774
FMMH	8.43±0.0333	469.33±3.38	331.0±6.03	0.533±0.0677	11.427±0.312	2.733±0.12	312.33±1.45	205.0±2.89	224.0±10.2	22.737±0.64
FROH	7.77±0.033	832.67±6.49	333.33±5.78	0.4667±0.0333	21.967±0.879	7.2±0.115	451.67±0.882	198.33±0.882	187.63±5.23	16.77±0.491
GPK	8.07±0.0333	654.67±2.4	307.0±1.53	0.233±0.0333	28.537±0.309	2.687±15.2	269.7±15.2	183.0±1.53	157.7±0.37	16.55±0.524
GJKD	7.73±0.033	570.0±0.577	177.0±1.53	0.333±0.0667	23.07±0.585	1.48±0.291	213.67±0.882	175.0±1.53	13.897±0.562	17.583±0.56
GDT	7.93±0.033	696.0±0.4.16	310.33±3.71	0.233±0.0333	20.833±0.0333	2.937±0.149	234.33±1.45	174.0±2.31	65.57±0.599	14.0±0.445
GGK	7.767±0.033	342.67±1.76	177.0±0.577	0.633±0.186	24.127±0.158	0.797±0.0353	205.67±0.882	157.67±0.882	78.43±0.709	11.677±0.542
GBQC	7.833±0.033	514.0±2	289.67±0.882	0.233±0.0333	24.067±0.322	1.857±0.238	291.0±2.08	234.33±1.2	28.257±0.408	30.453±0.734
GND	7.767±0.0333	754.33±2.96	359.67±1.2	0.233±0.0333	19.333±0.338	0.443±0.384	335.0±1.53	218.0±1.53	74.23±0.894	22.26±0.455
GDTH	8.00±0.0577	140.67±1.2	517.0±1.53	0.433±0.0882	20.8±0.643	36.03±1.39	372.33±1.45	222.67±1.76	74.493±0.555	21.967±0.797
GBLP	6.867±0.067	113.3±1.76	280.33±0.882	0.3667±0.0333	36.17±0.937	7.063±0.252	374.33±2.19	263.67±2.03	64.207±0.527	33.467±0.781
PKC	7.9667±0.0333	859.6±6.03	325.0±2.65	0.216±0.0167	29.657±0.447	13.48±0.452	210.0±0.577	206.0±3.21	85.17±1.42	48.867±0.578
PDH	7.10±0.0577	107.33±3.71	421.67±3.53	0.203±0.003	22.333±0.524	7.679±0.033	153.33±1.76	205.33±3.18	97.6±0.781	55.87±1.02
PPP	7.67±0.033	109.0±1.15	406.0±2.31	0.3±0.057	4.70±0.321	7.367±0.186	253.33±1.76	205.67±2.4	67.37±1.2	35.3±0.624
PDTL	7.57±0.0333	105.67±2.96	321.67±1.2	0.267±0.033	5.60±0.929	6.90±0.057	206.0±3.06	255.67±2.96	127.0±3.21	24.2±0.265
TMKP	7.7±0.0577	391.67±6.84	825.67±5.36	0.6±0.0577	32.06±0.851	1.7±0.404	350.0±2.89	127.1±8.98	37.557±0.482	21.66±0.419
TBJ	7.9±0.0577	228.67±4.37	468.7±19.1	0.733±0.0667	33.327±0.68	1.567±0.296	252.33±0.882	107.33±1.45	37.557±0.482	21.66±0.419
TWTS	7.33±0.0667	429.0±1.53	642.0±3.06	0.733±0.0667	22.73±0.644	0.20±0.115	547.33±3.38	152.67±1.45	66.99±1.04	24.493±0.288
TKL	8.133±0.033	755.67±5.36	312.33±3.93	0.6±0.0577	32.067±0.851	1.767±0.384	350.0±2.89	253.0±2.08	57.99±0.705	23.44±0.326
TMK	7.767±0.033	392.67±5.84	820.67±5.21	1.433±0.12	33.667±0.882	7.67±0.088	555.33±2.91	107.0±3.61	56.54±1.22	21.963±0.546
TDL	6.9±0.0577	273.0±.2.08	647.0±1.53	0.8±0.0577	22.00±0.866	0.167±0.082	252.33±0.882	106.0±0.577	36.23±1.15	32.157±0.539

Table 4.23: Physico-chemical parameters (Mean± SE) analysed in Municipal water (MW) samples collected from Border villages of Punjab

site	pH	EC (µS/cm)	TDS (mg/l)	Fluoride(mg/l)	Chloride(mg/l)	Nitrate(mg/l)	Alkalinity(mg/l)	Hardness(mg/l)	SO4(mg/l)	Mg(mg/l)
ABK	7.3667±0.0333	200±0.578	190±0.557	0.46±0.033	11.4±0.404	0.7±0.265	352.0±1.15	352.33±1.86	57.867±0.477	12.35±0.267
ARNN	6.7±0.0577	153.33±1.76	211.67±1.2	0.333±0.067	11.17±0.328	1.46±0.296	212.33±1.45	221.0±1.0	70.03±1.55	24.28±0.391
AHM	6.8±0.0333	212.0±1.15	307.0±1.53	0.1±0.05777	29.657±0.447	0.5667±0.0667	551.67±0.882	205.67±2.33	71.93±0.872	30.5±0.629
ABH	6.8±0.0577	146.33±0.882	290.0±1.15	0.667±0.0333	13.257±0.308	1.20±0.208	324.33±2.33	352.33±0.882	58.357±7.02	16.173±0.365
ABA	6.8±0.0577	342.33±1.76	110.0±1.15	0.4667±0.	12.45±0.507	1.293±0.416	253.67±0.333	203.33±0.882	71.803±0.721	13.44±0.451
ADK	6.5±0.0577	167.33±1.2	164.7±0.882	0.1667±0.033	11.233±0.41	1.233±0.145	307.33±3.71	206.67±3.33	64.02±0.76	15.093±0.542
ZARNW	7.8±0.033	483.33±4.48	221.0±5.57	0.3933±0.0291	11.533±0.581	2.6±0.0577	299.67±6.06	207.0±3.51	183.00±1.53	12.11±0.173
ZDQ	6.7±0.0577	132.0±0.577	406.33±3.18	1.16±0.03	32.06±0.851	2.733±0.012	189.33±3.18	251.0±2.52	171.98±1.21	41.353±0.373
ZASF	7.1±0.608	209.33±5.81	177.0±0.577	1.16±0.03	20.47±1.07	2.667±0.12	352.33±1.2	211.0±6.08	218.54±1.53	30.47±0.734
ZMJ	6.2667±0.0333	241.67±1.2	391.6±6.84	0.01±0.005	20.8±0.648	7.367±0.186	152.0±1.15	368.67±5.55	127.1±3.21	35.3±0.624
FJHC	7.1±0.068	751.67±4.98	328.67±3.33	0.6±0.0577	21.463±0.592	2.633±0.067	455.33±1.2	251.0±0.577	187.63±5.23	17.74±0.581
FKRM	8.1±0.0577	746.0±2.08	328.0±4.16	0.233±0.033	22.213±0.455	0.51±0.0677	309.67±4.84	107.33±1.45	209.33±6.36	22.117±0.664
FBKE	8.1±0.0577	301.6±0.882	133.0±1.73	1.1667±0.0.033	20.83±0.033	21.667±0.0.419	350.33±2.88	207.67±3.71	188.82±5.86	14.127±0.37
FHZ	7.2±0.185	105.6±2.96	315.0±3.21	0.4667±0.033	11.773±0.598	0.2667±0.0667	205.07±2.89	152.67±6.11	205.19±3.72	10.013±0.86
FMMH	8.4333±0.0333	482.67±1.76	328.0±4.16	0.4667±0.0667	2.6333±0.0667	2.733±0.12	309.67±4.84	152.67±1.33	209.33±6.36	22.117±0.664
FROH	7.77±0.577	832.67±6.49	314.33±1.45	0.333±0.0333	21.29±0.554	2.5333±0.0333	428.67±2.96	183.0±1.53	206.4±12.2	14.753±0.867
GPK	7.633±0.0333	557.67±4.98	188.67±1.86	0.233±0.0333	17.097±0.755	1.403±0.335	187.0±1.73	167.0±1.53	11.403±0.712	14.447±0.428
GJKD	7.8±0.05667	534.33±2.19	122.33±1.45	0.2333±0.0333	18.977±0.603	1.01±0.0709	205.67±2.96	169.67±0.882	6.133±0.531	16.55±0.524
GDT	7.5333±0.0333	407.33±1.33	327.33±1.45	0.233±0.0333	39.213±0.777	0.6567±0.0581	207.33±3.71	159.33±1.76	65.55±0.599	13.48±0.452
GGK	7.3±0.05667	335.33±1.45	172.0±1.45	0.4667±0.0333	18.917±0.922	0.733±0.0.0667	249.33±3.53	152.267±6.11	74.49±0.555	11.733±0.598
GBQC	7.8667±0.0333	511.67±0.882	202.67±2.19	0.1±0.0577	14.933±0.546	1.67±0.203	237.67±0.882	217.67±0.882	28.53±0.309	16.55±0.524
GND	7.833±0.0333	121.0±1.15	174.33±1.76	0.3±0.0577	12.7±0.473	0.51±0.0667	174.0±1.73	169.67±0.882	19.177±0.611	17.103±0.774
GDTH	7.6±0.05667	133.0±1.15	327.33±1.45	0.333±0.067	22.153±0.628	0.6733±0.0593	203.33±1.76	218.0±1.53	20.793±0.678	22.26±0.455
GBLP	6.7±0.0577	106.0±5.57	281.0±0.882	0.2333±0.0333	38.96±0.633	0.61±0.0473	351.67±1.15	234.33±1.2	7.297±0.444	30.47±0.45
PKC	6.3667±0.0882	394.33±2.96	209.67±1.45	0.19667±0.0033	24.127±0.158	11.67±0.542	206.0±3.06	153.67±1.86	25.5±1.27	43.733±0.895
PDH	2.9667±0.0882	107.33±3.71	406.0±2.31	0.2±0.003	2.97±0.505	7.367±0.186	152.0±1.15	154.33±2.19	56.23±1.33	34.57±1.21
PPP	7.6667±0.0333	105.67±2.96	202.67±9.33	0.233±0.333	2.667±0.203	7.063±0.252	234.33±1.2	204.0±2.85	34.43±1.03	27.767±0.578
PDTL	7.6±0.0333	104.67±2.91	314.3±1.45	0.233±0.333	4.71±0.32	6.7±0.057	153.33±1.76	206.0±3.21	96.77±1.45	14.0±0.755
TMKP	7.6333±0.0882	222.67±4.81	549.0±2.65	0.5667±0.0333	31.93±0.0636	1.48±0.291	335.0±8.39	128.1±3.09	33.32±0.68	19.42±0.678
TBJ	7.633±0.145	161.0±3.21	309.0±6.66	0.6±0.577	30.2±1.26	2.0±0.127	249.33±3.53	105.33±2.73	36.14±0.937	17.103±0.774
TWTS	7.5667±0.0333	152.67±1.2	392.67±4.1	0.6±0.577	13.1±1.59	0.2±0.115	453.67±1.86	152.0±1.15	68.56±0.502	23.44±0.326
TKL	7.3667±0.0667	251.67±4.41	310.0±3.71	0.5333±0.0333	31.933±0.636	1.7±0.404	352.33±0.882	254.67±2.4	53.66±0.882	22.26±0.455
TMK	7.6±0.0577	219.33±1.76	551.67±0.882	0.7±0.0577	31.967±0.888	0.133±0.0667	352.33±1.2	107.67±1.46	56.64±1.22	21.29±0.554
TDL	6.6333±0.0333	246.0±1.2	642.0±3.06	0.733±0.067	21.837±0.506	0.167±0.082	253.67±1.76	105.67±2.96	33.0±0.68	33.46±0.781

Table 4.24: Summary of physico-chemical parameters estimated in water samples collected from Border villages of Punjab

Parameter/units	**Limit**	**Range (GW)**	**Range (MW)**	**% samples above limit (GW)**	**% samples above limit (MW)**
pH	6.50-8.50	6.60-8.50	6.6-8.43	-	-
Electrical conductivity (µS/cm)	900.00	105.67-859.6	104.6-832.6	-	-
Total dissolved solids (mg/l)	500.00	150.0-825.6	110.0-642.0	14.7	8.8
Total alkalinity (mg/l)	200.00	153.3-555.3	152.0- 455.3	97	85.3
Total hardness (mg/l)	200.00	103.0-381.0	105.3-368.6	64.7	47
Chlorides (mg/l)	250.00	0.50-38.96	2.63-39.21	-	-
Fluorides (mg/l)	1.00	0.01-1.567	0.01-1.16	14.7	8.8
Sulphates (mg/l)	200.00	13.89-232.87	6.13-218.54	17.6	14.7
Nitrates (mg/l)	45.00	0.167-36.03	0.26-21.66	-	-
Magnesium (mg/l)	30.00	11.67-80.693	10.01-43.73	29.4	23.5

Table 4.25 and 4.26 figure 4.20, present the details of heavy metal analysis carried out on municipal water & groundwater samples respectively.

Table 4.25: Heavy metal (Mean± SE) analysis in Municipal water samples collected from Border Villages of Punjab

Site	Cadmium	Selenium	Arsenic	Lead	Nickel	Uranium	Chromium	Iron
ABK	ND	ND	0.004±0.003	0.001±0.003	ND	0.017±0.0005	ND	0.027±0.008
ARNN	ND	ND	0.001±0.003	0.0037±0.007	ND	0.027±0.008	ND	0.02±0.005
AHM	ND	ND	0.001±0.003	0.0043±0.0003	0.001±0.003	0.002±0.0005	ND	0.01±0.0029
ABH	ND	0.0017±0.0085	0.001±0.003	0.0023±0.0005	0.001±0.003	0.024±0.0005	ND	0.02±0.005
ABA	0.0001±0.00003	ND	0.0001±0.00003	0.0005±0.0007	0.001±0.003	0.007±0.0006	0.00013±0.00003	0.0172±0.0006
ADK	ND	ND	0.0002±0.00007	0.014±0.0011	ND	0.002±0.0005	0.011±0.0009	ND
ZARNW	ND	0.0036±0.0008	0.001±0.0008	0.0037±0.0003	0.005±0.0006	0.016±0.0005	ND	0.009±0.0001
ZDQ	ND	0.0014±0.0003	0.001±0.0046	0.004±0.0005	0.0053±0.0003	0.016±0.0005	0.0013±0.0003	0.0057±0.0003
ZASF	ND	0.0014±0.0003	0.001±0.0054	0.002±0.0005	0.001±0.003	0.013±0.0005	ND	0.013±0.003
ZMJ	ND	0.0046±0.0008	0.0027±0.0008	0.003±0.0008	0.002±0.0005	0.006±0.0005	0.0027±0.0003	0.016±0.0.0005
FJHC	ND	0.0023±0.0003	ND	0.0023±0.003	ND	0.017±0.0005	ND	0.028±0.0020
FKRM	ND	0.0001±0.00003	0.0017±0.0003	0.0005±0.00005	ND	0.006±0.0005	ND	0.006±0.0005
FBKE	ND	0.0050±0.0003	0.001±0.003	0.0047±0.0007	0.001±0.003	0.013±0.003	ND	0.005±0.00067
FHZ	ND	0.00017±0.00003	0.001±0.0008	0.0076±0.0003	0.0023±0.0006	0.003±0.0005	ND	0.017±0.0005
FMMH	ND	0.00007±0.00003	0.0027±0.00021	0.006±0.0004	0.0018±0.0003	0.006±0.0005	0.00013±0.00006	0.013±0.003
FROH	ND	0.0003±0.00003	0.0012±0.003	0.003±0.0024	0.0026±0.0003	0.007±0.0006	0.0002±0.00006	0.01±0.0029
GPK	ND	0.0001±0.00003	0.0233±0.0067	0.0001±0.00003	ND	0.006±0.0005	ND	0.02±0.005
GJKD	ND	ND	0.001±0.003	ND	ND	0.003±0.0005	ND	0.02±0.005
GDT	ND	0.00023±0.00003	0.003±0.0008	0.0003±0.00003	ND	0.003±0.0005	ND	0.01±0.0029
GGK	ND	ND	0.0167±0.0033	0.0003±0.00003	ND	0.017±0.0033	ND	ND
GBQC	ND	0.0001±0.00003	0.02±0.0006	ND	ND	0.002±0.0005	ND	0.0267±0.008
GND	ND	0.0001±0.00003	ND	0.0013±0.003	ND	0.016±0.0005	ND	ND
GTU	ND	ND	ND	0.001±0.003	ND	0.003±0.0005	ND	0.027±0.008
GBLP	ND	0.0001±0.00003	ND	ND	ND	0.003±0.0005	ND	ND
PKC	0.0001±0.0.00003	0.00067±0.0003	0.0014±0.0003	0.002±0.0005	0.001±0.003	0.007±0.0006	ND	0.0123±0.002
PDH	ND	0.0001±0.00003	ND	0.002±0.0005	0.013±0.003	0.013±0.003	ND	0.015±0.0005
PPP	ND	0.0027±0.0007	ND	0.001±0.003	0.013±0.003	0.013±0.003	ND	0.015±0.008
PDTL	ND	ND	ND	0.001±0.003	0.001±0.003	0.013±0.003	ND	0.0123±0.002
TMKP	0.00013±0.00003	0.0001±0.00003	ND	ND	ND	0.017±0.0005	ND	0.001±0.003
TBJ	0.00013±0.00003	0.001±0.01	ND	ND	ND	0.016±0.0005	0.0006±0.0005	0.026±0.008
TWTS	ND	ND	ND	0.002±0.0005	0.0026±0.0003	0.010±0.0029	ND	0.015±0.0005
TKL	0.003±0.0008	0.002±0.0005	ND	0.007±0.0006	0.003±0.0008	0.010±0.0029	0.0003±0.0001	ND
TMK	0.0001±0.00003	0.0027±0.0003	ND	0.010±0.0029	0.0037±0.0003	0.013±0.003	ND	0.015±0.0005
TDL	0.0001±0.0003	0.0027±0.0008	ND	0.002±0.0005	0.001±0.003	0.017±0.0005	ND	0.012±0.0.0005

Table 4.26: Heavy metal (Mean± SE) analysis in Ground water (GW) samples collected from Border Villages of Punjab

SITE	**Cadmium**	**Selenium**	**Arsenic**	**Lead**	**Nickel**	**Uranium**	**Chromium**	**Iron**
PKC	0.0003±0.0003	0.0020±0.0005	ND	0.0047±0.0008	0.0010±0.003	0.0075±0.003	ND	0.036±0.0050
PDH	ND	0.0017±0.0003	ND	0.0027±0.0003	0.0130±0.0003	0.0347±0.003	ND	0.022±0.0017
PPP	ND	0.0027±0.0003	ND	0.0030±0.0005	0.0130±0.003	0.0133±0.003	ND	0.029±0.0080
PDTL	ND	ND	ND	0.0037±0.0003	0.0060±0.0005	0.0180±0.0017	ND	0.013±0.0030
GPK	ND	0.00016±0.00006	0.03±0.0067	0.0027±0.0008	ND	0.00813±0.003	ND	0.02±0.0088
GJKD	ND	ND	0.016±0.0057	ND	ND	0.00467±0.003	ND	0.023±0.0057
GDT	ND	0.0076±0.00003	0.013±0.0033	0.0026±0.0007	ND	0.013±0.003	ND	0.050±0.006
GGK	ND	ND	0.016±0.0043	0.0013±0.0006	ND	0.034±0.005	ND	0.0130±0.003
GBQC	0.0001±0.00006	0.0002±0.00006	0.03±0.0006	0.0027±0.0003	ND	0.0041±0.003	0.00025±0.00006	0.0267±0.008
GND	ND	0.0016±0.0009	0.001±0.003	0.0023±0.0007	ND	0.0367±0.003	ND	0.026±0.008
GTU	ND	0.0076±0.003	0.013±0.007	0.003±0.0006	ND	0.0133±0.003	ND	0.05667±0.008
GBLP	ND	0.0002±0.0000	0.013±0.0067	0.007±0.0006	ND	0.0078±0.001	ND	0.030±0.005
ABK	ND	ND	0.012±0.0033	0.0016±0.0008	0.0060±0.0005	0.0034±0.005	ND	0.031±0.005
ARNN	0.0001±0.00006	0.0023±0.0006	0.013±0.00013	0.006±0.007	0.013±0.0003	0.036±0.008	0.00013±0.00003	0.02±0.0032
AHM	ND	ND	0.013±0.0023	0.0073±0.0003	0.001±0.003	0.004±0.005	0.00013±0.00003	0.02±0.0032
ABH	ND	0.03±0.0085	0.017±0.002	0.0043±0.0008	0.001±0.007	0.003±0.008	0.010±0.0008	0.032±0.0057
ABA	0.0001±0.00006	0.0001±0.00006	0.015±0.0023	0.0029±0.001	0.001±0.00015	0.0083±0.008	0.00013±0.00003	0.032±0.0006
ADK	ND	0.0008±0.0003	0.004 ±0.0008	0.0175±0.0011	0.0039±0.000	0.00491±0.008	0.011±0.0009	0.026±0.0088
TDL	ND	0.0267±0.0029	ND	0.0050±0.0003	0.0030±0.0030	0.0187±0.005	0.0002±0.00005	0.0146±0.0203
TMK	0.0013±0.0003	0.011±0.0006	ND	0.0103±0.0008	0.0053±0.0003	0.0253±0.003	0.0001±0.00005	0.0164±0.0043
TKL	0.001±0.0005	0.0060±0.0005	ND	0.0160±0.002	0.00367±0.0003	0.0171±0.0001	0.0033±0.0008	0.013±0.0030
TWTS	ND	ND	ND	0.0063±0.0003	0.0043±0.0003	0.0114±0.0029	0.00013±0.00003	0.015±0.0037
TBJ	0.0001±0.00006	0.0017±0.0001	ND	ND	ND	0.0187±0.0017	0.0013±0.00003	0.0267±0.0088
TMKP	0.0002±0.00006	0.0002±0.0000	ND	ND	ND	0.0253±0.0.005	ND	0.013±0.0003
FJHC	ND	0.0041±0.0001	0.003±0.0005	0.007±0.003	0.0010±0.003	0.0227±0.0.008	ND	0.0287±0.0020
FKRM	ND	0.0004±0.0000	0.0060±0.0005	0.0017±0.0003	0±0.0000	0.0107±0.0.003	ND	0.0180±0.0017
FBKE	ND	0.0049±0.0001	0.013±0.0005	0.006±0.003	0.0010±0.003	0.0173±0.0001	ND	0.0053±0.0003
FHZ	ND	0.0010±0.003	0.0017±0.003	0.0300±0.005	0.0030±0.003	0.0057±0.0003	6.66667E-05	0.0273±0.0001
FMMH	ND	0.0001±0.00006	0.0047±0.003	0.0074±0.0007	0.0040±0.0005	0.0099±0.0001	0.0005±0.0000	0.0103±0.0029
FROH	ND	0.0001±0.003	0.003±0.0033	0.0044±0.0008	0.0110±0.0009	0.0097±0.0000	0.0002±0000	0.0100±0.0029
ZARNW	ND	0.0043±0.0003	0.001±0.001	0.0053±0.0008	0.0230±0.008	0.0250±0.0005	ND	0.0110±0.0029
ZDQ	ND	0.0017±0.0001	0.001±0.0033	0.0057±0.0003	0.0073±0.0003	0.0172±0.0005	0.0002±0.0005	0.0130±0.0030
ZASF	ND	0.0016±0.0017	0.001±0.003	0.005±0.005	0.0200±0.005	0.0107±0.0029	ND	0.0170±0.0005
ZMJ	ND	0.0083±0.0001	0.0060±0.0005	0.007±0.008	0.0060±0.0005	0.01740±0.0005	0.0003±0.0005	0.0160±0.0033

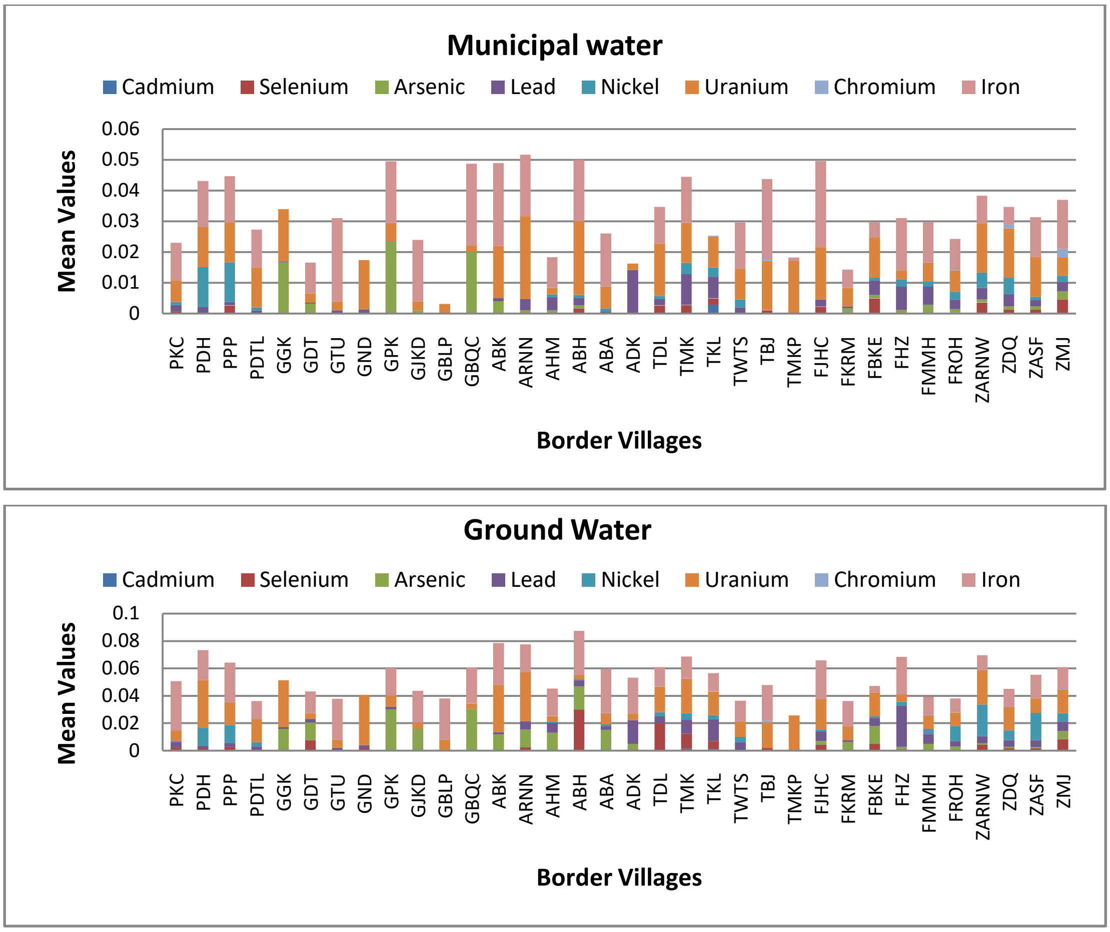


Fig. 4.20: Heavy metal analysis of municipal water & ground water samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 “Materials and Methods” (Table 3.2).

4.3.1 pH

The pH values obtained from the collected ground as well as municipal water samples from the various villages selected for the present work shows the mean value for pH for groundwater samples was 7.48 with minimum value 6.7 at site ABH, ZMJ and maximum value 8.43 at site FMMH. Similarly, the pH value of municipal water samples was from 2.96 to 8.43. The mean value was obtained was 7.2. The range was well within the Indian standards for drinking water quality although the water samples are majorly alkaline in nature.

4.3.2 Total dissolved solids (TDS)

The highest and lowest values of TDS was obtained at site TMKP and at site FBKE with the values 825.67 mg/l and 150 mg/l respectively in ground water. The mean value of total dissolved solids was 368.97 mg/l. In municipal water the values ranged from

110 mg/l at site ABA to 642 mg/l at site TDL. The mean value was 376.0 mg/l. Out of the 34 samples analysed only few samples had the TDS values limit beyond the permissible limit of 500 mg/l as per BIS guidelines. As per the classification based on drinking water suitability, all the water samples under study are fresh water in nature.

4.3.3 Electrical conductivity (EC)

It is an indicator of salinity of water and in majority of the samples a wide variation has been observed. The mean value of electrical conductivity in the groundwater was 401.61µS/cm and the highest value was obtained at site PKC, FJHC 859.6µS/cm and lowest at site PDTL 105.67µS/cm respectively in ground water samples. It has minimum value was 104.67 µS/cm at site PDTL and maximum was 832.6µS/cm at site TDL. In municipal water none of the samples were in the excellent category as per the US Salinity Laboratory shown in table 4.27.

Table 4.27: Classification of groundwater samples of the study area on the basis of Total hardness and Total dissolved solids for drinking water suitability

Parameters	**Range**	**Water class**	**No. of samples**
Total dissolved solids (TDS) mg/l	<300	excellent	16
	300-600	Good	17
	600-900	Fair	1
	900-1200	Poor	-
	>1200	Unacceptable	-
Nature of ground water based on TDS value	0-1000	Fresh	34
	1001-10,000	Brackish	-
	10,001-100,000	Salty	-
	>100,000	Brine	-
Salinity hazard (EC) µS/cm	<250	Excellent	20
	250-750	Good	11
	750-2000	Permissible	2
	2000-3000	Doubtful	-
	>3000	Unsuitable	-
Total Hardness (TH) mg/l **(*Sawyer and McCarty,1967*)**	<75	Soft	-
	75-150	Moderately hard	4
	150-300	Hard	27
	>300	Very Hard	3

#The US Salinity Laboratory (USSL)

4.3.4 Total Alkalinity (TA)

The groundwater and municipal water samples were analysed for the alkalinity content. The mean alkalinity value for groundwater was 337.55 mg/l with the minimum value is at site PDH 153.3 mg/l and maximum value 555.3 mg/l was obtained at site TMK. Similarly, mean value of municipal water was 282.68 mg/l with minimum value 152.0 mg/l at site ZMJ, PDH and maximum value 455.33 mg/l was obtained at site FJHC.

4.3.5 Total hardness (TH)

Hardness of water is also an important quality criterion both for domestic as well as irrigation purposes. It is due to the chlorides of calcium or magnesium and carbonates & sulphates, in water. The hardness of ground water samples collected from all the locations under study varied from 103.0 mg/l at FKRM to 381.0 mg/l at ZMJ respectively. The mean value of the hardness was 218.51mg/l. In municipal water, total hardness ranges from 105.33 mg/l at TBJ site to 368.67 mg/l at ZMJ site. The mean value was 196.84 mg/l. Some of the water samples showed the values above the permissible limits as given by BIS drinking water quality standards.

The minimum value of magnesium reported at site GGK was 11.67 mg/l and maximum 80.69 mg/l at site ZDQ for ground water samples. The mean value was 25.07 mg/l The maximum value 43.73 mg/l was obtained at site PKC and minimum value of 10.01 mg/l at site FHZ for municipal water samples of the present work. The mean value was 21.52 mg/l.

4.3.6 Chlorides

The samples of ground as well as municipal water quality were analysed for the chloride content. The highest value was at site ZDQ 38.967 mg/l and the lowest at PPP site 4.70 mg/l respectively with the mean value of 22.81mg/l in ground water samples. Similarly, in the municipal water the highest content was 39.213 mg/l at site GDT and lowest value of 2.63 mg/l at site FMMN respectively. The mean value was 19.19 mg/l. All the water samples analysed for chloride content were well within the permissible limits.

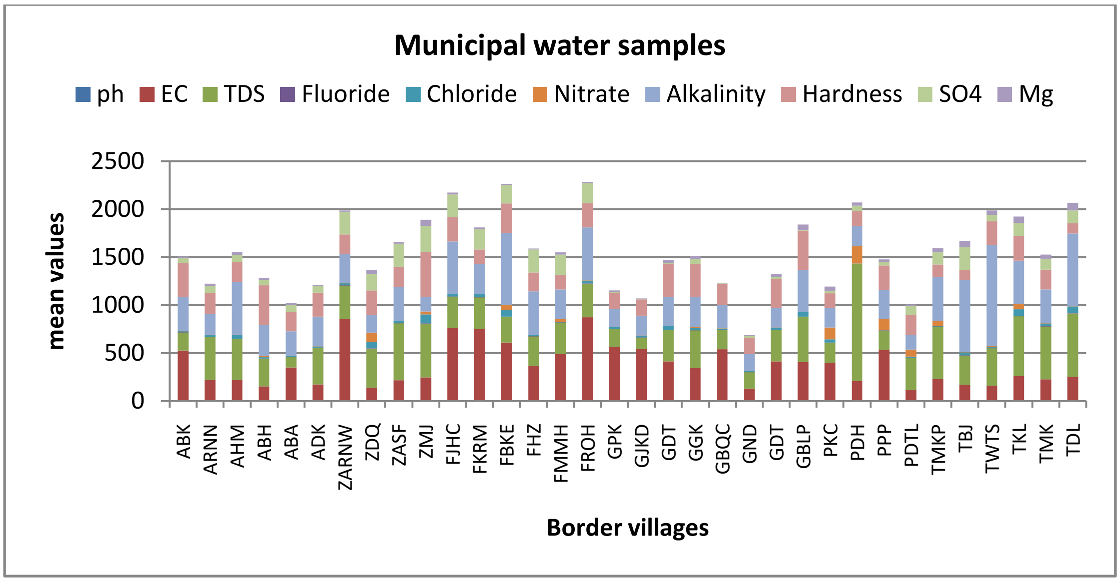


Fig. 4.21: Physico-chemical parameter of municipal water samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 "Materials and Methods" (Table 3.2).

4.3.7 Fluorides

Concentration of fluoride ions in the collected samples from all the 34 sites taken up under the study is shown in table 4.25, 4.26 and Fig. 4.30, 4.31. The minimum value of fluoride ion was 0.01mg/l and the maximum were 1.567mg/l obtained at site ZMJ and ABH respectively in the ground water samples. The mean value was 0.567 mg/l. In drinking water, the content was 0.01 mg/l and 1.16 mg/l as the minimum and maximum values respectively. The mean value was 0.438 mg/l is well within the permissible limit except at few sites where it was beyond the desirable limit for drinking water quality as given by Indian standards.

4.3.8 Sulphates

The concentration of sulphate in ground water was found to be highest 232.87 mg/l at site FRKM and lowest value was 13.897 mg/l at site GJKD respectively. The mean value for sulphate content in these samples was 106.35 mg/l. While the concentration of sulphate in the municipal water samples, the maximum was 218.54 mg/l at site ZASF and minimum was 6.133 mg/l at site GJKD. The mean value of sulphate was 89.08 mg/l.

4.3.9 Nitrates

The content of nitrates in ground water was highest at site PKC 36.03 mg/l and lowest at site TDL 0.2mg/l respectively. The mean value for nitrate content in these samples was 11.86 mg/l. While the content of nitrate in municipal water samples obtained from the various locations under study, the maximum was 21.66 mg/l at site FHZ and minimum value was 0.133 mg/l at site TMK. The mean value of nitrate was 2.87 mg/l.

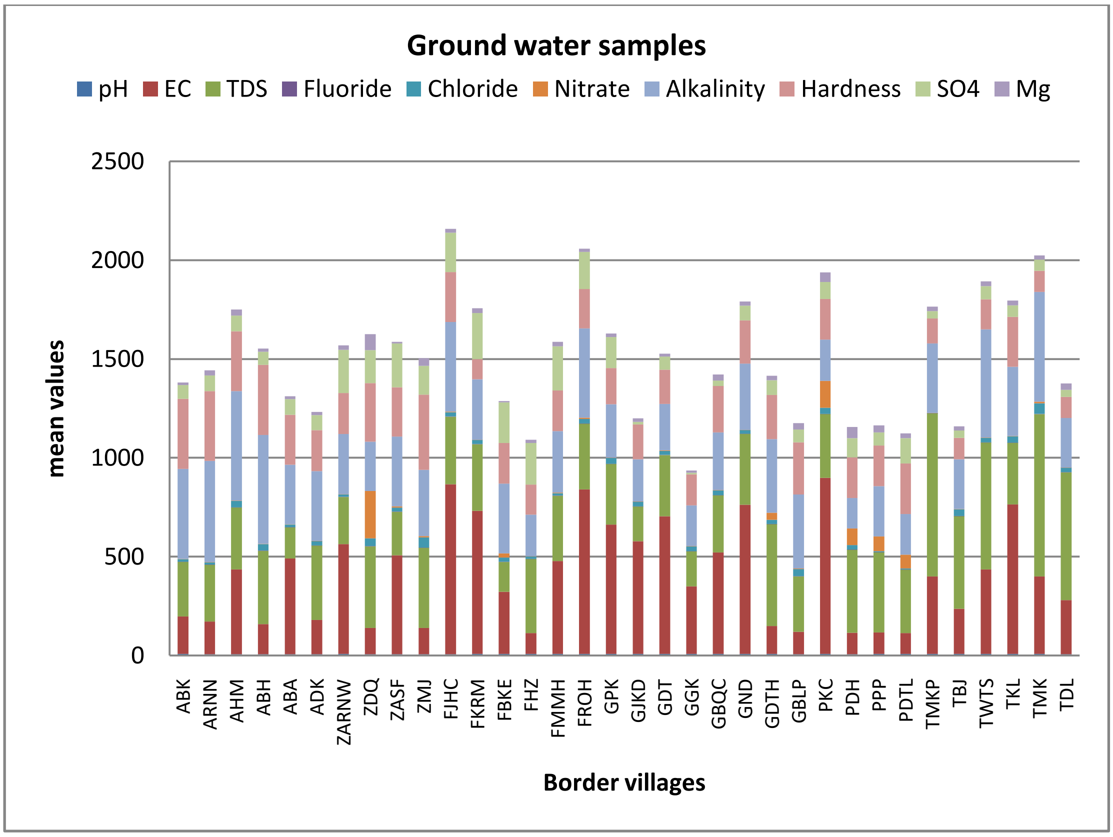


Fig. 4.22: Physico-chemical parameter of ground water samples collected from border villages of Punjab

#Sample codes are described in detail in chapter 3 “Materials and Methods” (Table 3.2).

4.3.10 Pearson correlation analysis of water & soil samples

The correlation matrix of the 10 parameters that were taken up for physico-chemical analysis was prepared with the help of mini tab 14 software. To measure the relationship among them, the values significant at P<0.05 are given in the correlation table 4.31 for the municipal water samples and in table 4.32 for ground water samples collected from the area under study. For municipal water samples all the parameters show negative correlation with one or more variables except a strong correlation with some parameters was observed. The correlation matrix also showed significant positive correlation between these parameters at p< 0.05 levels.

Table 4.28: Pearson correlation matrix of physico-chemical parameters of Municipal water samples of Border districts of Punjab

	pH	**EC (µS/cm)**	**TDS (µS/cm)**	**Fluoride (mg/l)**	**Chloride (mg/l)**	**Nitrate (mg/l)**	**Alkalinity (mg/l)**	**Hardness (mg/l)**	**SO4 (mg/l)**	**Mg (mg/l)**
pH	1									
EC (µS/cm)	0.343*	1								
TDS (µS/cm)	-0.185	-0.136	1							
Fluoride (mg/l)	0.144	-0.155	0.161	1						
Chloride (mg/l)	0.119	0.068	0.327	0.196	1					
Nitrate (mg/l)	-0.119	-0.027	-0.214	0.198	-0.147	1				
Alkalinity (mg/l)	0.223	0.237	0.101	0.232	0.26	-0.133	1			
Hardness (mg/l)	-0.139	-0.162	-0.264	-0.021	-0.109	0.108	0.053	1		
SO4(mg/l)	0.176	0.377*	0	0.399*	-0.135	0.206	0.257	0.054	1	
Mg(mg/l)	-0.509	-0.251	0.359*	0.061	0.215	0.204	-0.084	0.043	-0.077	1

Significance at p<0.05 value

The above table 4.28 showing the correlation between physico-chemical parameters of municipal water in the selected border villages. There has been found a positive correlation with pH-EC (r=0.343), EC-SO^-_4 (r=0.377), TDS-Mg (0.359) and F-SO^-_4(r=0.399). Similarly, a negative correlation has been found between many of the parameters significant at P <0.05 value.

Table 4.29: Pearson correlation matrix of physico-chemical parameters of ground water samples of Border Villages of Punjab

	pH	**EC**	**TDS**	**Fluoride**	**Chloride**	**Nitrate**	**Alkalinity**	**Hardness**	**SO4**	**Mg**
pH	1									
EC	0.473*	1								
TDS	-0.018	-0.184	1							
Fluoride	-0.167	-0.097	0.202	1						
Chloride	-0.194	0.012	0.162	0.247	1					
Nitrate	-0.2	-0.215	0.052	0.253	0.252	1				
Alkalinity	-0.284	0.036	0.252	0.421*	0.233	-0.139	1			
Hardness	-0.53	-0.262	-0.403	-0.026	0.115	0.192	0.342*	1		
SO4	0.11	0.191	-0.267	0.15	-0.13	0.173	-0.028	0.06	1	
Mg	-0.266	-0.229	0.214	-0.14	0.312	0.684*	-0.257	0.18	-0.027	1

Significance at p<0.05 value

The above table 4.29 shows a correlation between the physico-chemical parameters of ground water samples with a strong positive correlation between Mg-NO_3 (r=0.684), pH-EC (r=0.473), TA-F^-(r=0.421) and TH-TA (r=0.342). There are also several negative correlations between the various physico-chemical parameters of the water samples obtained from the ground water of the area under study.

Table 4.30: Pearson correlation matrix of heavy metal analysis of municipal water samples of Border Villages of Punjab

	Cadmium	**Selenium**	**Arsenic**	**Lead**	**Nickel**	**Uranium**	**Chromium**	**Iron**
Cadmium	1							
Selenium	0.125	1						
Arsenic	-0.092	-0.193	1					
Lead	0.236	0.212	-0.262	1				
Nickel	0.057	0.261	-0.21	0.1	1			
Uranium	-0.01	0.264	-0.158	-0.115	0.121	1		
Chromium	-0.015	0.053	-0.084	0.614*	-0.065	-0.236	1	
Iron	-0.265	-0.038	0.158	-0.264	-0.035	0.055	-0.248	1

Significance at p<0.05 value.

The table 4.30 shows the correlation between heavy metals of municipal water samples. a positive correlation between Pb-Cr (r=0.614) and some negative correlation between other heavy metals.

Table 4.31: Pearson correlation matrix of heavy metal analysis of ground water samples of Border Villages of Punjab

	Cadmium	**Selenium**	**Arsenic**	**Lead**	**Nickel**	**Uranium**	**Chromium**	**Iron**
Cadmium	1							
Selenium	0.183	1						
Arsenic	-0.196	0.029	1					
Lead	0.258	0.081	-0.232	1				
Nickel	-0.037	0.008	-0.366	0.053	1			
Uranium	0.146	-0.062	-0.235	-0.167	0.144	1		
Chromium	0.155	-0.014	-0.113	-0.029	-0.085	-0.015	1	
Iron	-0.062	0.075	0.121	0.071	-0.142	-0.435	0.029	1

The above table 4.31 shows no significant positive co- relation between the heavy metals detected in samples of ground water of the study area.

Table 4.32: Pearson correlation matrix of Heavy metals and physico-chemical parameters of municipal water samples collected from the Border districts.

	Cadmium	**Selenium**	**Arsenic**	**Lead**	**Nickel**	**Uranium**	**Chromium**	**Iron**	**pH**	**EC**	**TDS**	**Fluoride**	**Chloride**	**Nitrate**	**Alkalinity**	**Hardness**	**SO4**
Selenium	0.218																
Arsenic	-0.129	-0.169															
Lead	0.188	0.212	-0.236														
Nickel	-0.003	0.157	-0.211	0.032													
Uranium	0.076	0.264	-0.163	-0.115	0.138												
Chromium	-0.038	0.053	-0.094	0.614*	-0.083	-0.236											
Iron	-0.249	0.009	0.128	-0.278	0.082	0.066	-0.252										
pH	-0.025	0.041	0.18	-0.07	-0.359	-0.101	-0.193	0.014									
EC	-0.066	-0.004	0.321	-0.165	-0.298	-0.24	-0.146	0.072	0.343*								
TDS	0.289	0.163	-0.287	0.109	0.158	0.148	-0.09	-0.077	-0.185	-0.136							
Fluoride	0.147	0.381*	-0.214	0.132	-0.077	0.467*	-0.163	-0.106	0.144	-0.155	0.161						
Chloride	0.247	0.093	-0.102	-0.067	-0.449	-0.169	-0.066	-0.327	0.119	0.068	0.327	0.196					
Nitrate	-0.098	0.54	-0.122	0.028	0.309	0.056	-0.006	-0.057	-0.119	-0.027	-0.214	0.198	-0.147				
Alkalinity	0.085	0.057	-0.206	0.216	-0.27	-0.016	-0.063	-0.098	0.223	0.237	0.101	0.232	0.26	-0.133			
Hardness	-0.012	0.275	-0.019	0.016	-0.011	0.152	0.196	0.206	-0.139	-0.162	-0.264	-0.021	-0.109	0.108	0.053		
SO4	-0.167	0.289	-0.132	0.273	0.058	0.026	0.008	-0.12	0.176	0.377*	0.00	0.399*	-0.135	0.206	0.257	0.054	
Mg	0.136	0.169	-0.303	-0.023	0.215	0.00	0.031	-0.08	-0.509	-0.251	0.359*	0.061	0.215	0.204	-0.084	0.043	-0.077

Significance at p<0.05 value.

Table 4.32 shows the correlation between heavy metals and physico-chemical parameters of municipal water samples. A correlation was found between pH – EC (0.343), EC-SO_4^- (0.377), TDS-Mg (0.359), SO_4-F^- (0.399), Se-F^-(r=0.381), Pb-Cr (r=0.614), U-F^- (0.467), in the municipal water samples.

Table 4.33: Pearson correlation matrix of Heavy metals and physico-chemical parameters of different ground water samples collected from the selected Border Villages.

	Cadmium	Selenium	Arsenic	Lead	Nickel	Uranium	Chromium	Iron	pH	EC	TDS	Fluoride	Chloride	Nitrate	Alkalinity	Hardness	SO_4^-	Mg
Cadmium	1																	
Selenium	0.183	1																
Arsenic	-0.196	0.029	1															
Lead	0.258	0.081	-0.232	1														
Nickel	-0.037	0.008	-0.366	0.053	1													
Uranium	0.146	-0.062	-0.235	-0.167	0.144	1												
Chromium	0.155	-0.014	-0.113	-0.029	-0.085	-0.015	1											
Iron	-0.062	0.075	0.121	0.071	-0.142	-0.435	0.029	1										
pH	0.246	-0.261	0.047	-0.162	-0.061	-0.005	0.148	-0.279	1									
EC	0.188	-0.137	0.127	-0.120	-0.020	-0.120	-0.073	-0.184	0.473*	1								
TDS	0.400	0.249	-0.454	0.067	-0.047	0.144	0.137	-0.148	-0.018	-0.184	1							
Fluoride	0.291	0.504*	-0.109	0.128	0.214	0.003	0.055	-0.112	-0.167	-0.097	0.202	1						
Chloride	0.436*	0.328	0.035	0.049	-0.108	-0.144	0.249	0.094	-0.194	0.012	0.162	0.247	1					
Nitrate	-0.058	-0.062	-0.145	-0.025	0.108	0.002	0.032	-0.084	-0.200	-0.215	0.052	0.253	0.252	1				
Alkalinity	0.246	0.255	0.032	0.081	-0.098	0.010	-0.06	0.055	-0.284	0.036	0.252	0.421*	0.233	-0.139	1			
Hardness	-0.197	0.126	0.217	-0.011	0.027	0.052	-0.149	0.272	-0.530	-0.262	-0.403	-0.026	0.115	0.192	0.342	1		
SO_4^-	-0.247	-0.146	-0.152	0.286	0.448*	-0.105	-0.100	-0.122	0.110	0.191	-0.267	0.150	-0.130	0.173	-0.028	0.060	1	
Mg	-0.003	-0.021	-0.290	-0.095	0.175	0.098	0.078	0.108	-0.266	-0.229	0.214	-0.140	0.312	0.684*	-0.257	0.180	-0.027	1

Significance at p<0.05 value.

While analysing the Pearson correlation between heavy metals and physico-chemical parameters of ground water samples (Table 4.33) of the study area there was found a strong, positive correlation between magnesium and nitrate, Mg-NO_3 (r=0.684), SO_4^--Ni (r=0.448), TA-F^- (r=0.421), pH -EC (r=0.473).

Objective 3: Analysis of Local problems specific of the Villages under study

4.4 Issues & Challenges of villages

One of the major drawbacks of the villages under taken for study is their location itself. Being situated near the international border is a serious problem due to which they are always at disadvantage. To have an insight into the individual problems the villages under study were surveyed to get a first-hand information of the different aspects of village life. Some villagers along with the village head were selected at random and were interviewed. Different questions relating to the socio-economic aspects of the villages were asked and the responses were recorded. Various rural issues were discussed that brought to light the problems of the villages. Each village was toured with the help of the local residents and various problematic areas were also visited. Some of the real problems/challenges which these villages face have been discussed below:

4.4.1 Problems of Villages of District Pathankot

4.4.1.1 Village Khojke Chak

The village has an allopathic as well as an Ayurvedic dispensary but both are in deplorable condition (Fig. 4.23). Doctors are available but they are always short of medicines. For ayurvedic dispensary demand for medicines has been given several times but still waiting. There is dire need of furniture and infrastructural upgradation.

Fig. 4.23 Dilapidated building

Drainage of waste/grey water is an issue for villagers. There is no proper drainage of the water and it gets stored in a walled pond which gives an ugly site. 10-15% population of this village still is without toilets. It is difficult to say that the village has effectively achieved Sustainable Development Goal 6, which ensures access to clean water and sanitation. Also, the Swachh Bharat Abhiyan/Mission aimed at eliminating open defecation in India is still to be achieved.

Due to lack of a veterinary dispensary for the cattle in the village people have to travel to nearby town for the treatment of sick animals. Thus, there is a strong demand by the villagers to set up one such dispensary in the village.

To make the village approachable and commuting easy, the villagers want a complete all weather peripheral road. This will resolve many petty issues of the people and make the life a little comfortable.

The village has a primary and a middle school for the education of the children. But the middle school has paucity of teachers and post of D.O. is lying vacant since long. This has a negative impact on the school education and the learning of the students.

4.4.1.2 Village Dhinda

The village has not received any grant under BADP programme for last seven years so there has not been much development in certain sectors. The village has tube-wells /borewells installed under various development plans but the project has not been completed because no pipelines have been laid since the inception of the project. It has been lying so since the past four years.

Fig. 4.24 Drainage Tank

Being near the international border line the farmers cannot diversify crops due to security reasons. Also, there is no grain market/food storage facility available in or around the village (Fig. 4.24).

Fig. 4.25 Sanitation issues

Solar panels have been installed at certain points for the working or running of Wi Fi and tube-wells but till date they are not in working state because the project is not complete.

Then another issue is availability of proper schools. There is a make-shift school of primary level and no middle school in the village. The children have to go to nearby areas for their education. Though the village has two Anganwadis but there is no proper building. Rather these Anganwadis are running from a make shift place since long.

Untreated municipal water is available to the villagers but with no pipelines laid yet. The villagers have to fill it in buckets and carry home for various purposes (Fig. 4.25). There is no facility of ATM or Bank in the village and is 5 - 10 km away. Agricultural Credit Society is available in this village. The grey water from the houses flows into a drain which is discharged directly into nearby natural water bodies, thus polluting the sources of rain water harvesting as well as rendering them unfit for animals.

4.4.1.3 Village Paharipur

The urgent need of this village is to treat the drainage of grey water. The water does not flow out but pollutes the water bodies. There are septic tanks for toilets and no sewage system. (Fig. 4.26)

Fig. 4.26 Faulty supply pump

A drain that contains the filthy water flows near the outer boundary of the village. Due to stink and ugliness this drain is a hindrance and nuisance to the progress and development of the village. There is no facility of dispensary/PHC in the village and it becomes difficult at times for people to handle emergencies.

The people also demand a gymnasium for the youth as they have nothing useful to do in the free time. So, to channelise their energies in a positive way an open-air gymnasium is needed.

4.4.1.4 Village Datyal

This village of district Pathankot is also deprived of the BADP programme funds given for various development purposes since long. Thus, some basic amenities are lacking in the village (Fig. 4.27).

Fig. 4.27 Waste Water Drain

One of the objectives of Swachh Bharat Abhiyan is to create an India totally ODF (open defecate free). Village Datyal has fallen short of achieving this SGD goal of clean health and sanitation because it is not 100% ODF. Only 25-30 houses out of 201 houses of the village having a population of 1004, have toilet in their houses, comprising a mere 15%.

The farmers practice traditional agriculture and have not procured any advanced agricultural implements. The reason is that procurement is difficult due to poor roads and tough terrain.

Just like many other villages of the border belt this village also has the issue of waste water drainage. Although they want a solution to it but nothing effective has been done by the government schemes and plans. A drain that flows at the outer of the village is a hindrance.

4.4.2 Problems of Villages of District Gurdaspur

4.4.2.1 Village Gadi Kalan

While surveying the study area it was found that this village is quite self-sufficient in almost all the basic amenities. The village is by and large better in most of the facilities which are lacking or are fewer in other villages. The only drawback this village has that there is no bank or ATM facility for which the people have to travel nearly 5 kilometres. There is availability of piped water supply in the village but it is without the RO facility.

4.4.2.2 Village Dostpur

The village has the major problem of waterlogging due to the fact that water is available at 30 to 40 feet below ground level. Due to such superficial level of ground water, it is very difficult to grow crops and nothing much has been done by the government and agriculture department to find a proper solution to this problem.

Secondly, this village does not have a proper supply of drinking water and people meet the demand of water consumption through hand pumps. It is quite possible that people are consuming a number of pollutants and contaminants along with water thus posing a risk to the health of one and all.

Thirdly, there is lack of a community hall or a Panchayat Bhawan which is also the demand. It really becomes difficult for them to hold religious and non-religious functions in the village. They have to spend extra money every time to arrange for such occasions. It becomes difficult for those who have meagre sources of income to make such arrangements.

4.4.2.3 Village Bharth Qazi Chak

This village does not possess the facility of a Bank or an ATM. The villagers have strongly put the demand for the same at the earliest.

There is no community hall or Panchayat Bhawan in the village. If this facility is made available to the people holding of functions of various kinds would become easier for the villagers and would save lots of time and energy.

The village has a school but there is no Anganwadi available. If the facility is provided it would become easy for the working women to send their children for daycare. Almost 50% of the houses have the drinking water facility and still another 50% has to be reached to achieve the target of clean drinking water for every one under Swachh Bharat Mission as well as SGD 6.

4.4.2.4 Village Nadala

This village is not well connected internally as well as externally through all-weather roads and hence no means of public transport is available. People have to commute on their own conveyance which is an extra burden on their pocket when resources are limited. But those who do not have any conveyance of their own they have to struggle to reach the nearby town or city to reach the bus stop.

There is no Primary Health centre or community health centre in the village for the immediate medical need of the villagers. The village also lacks a veterinary dispensary and people have to either take their sick animals to the nearest facility or they have to bring the doctor to the village to check the ailing animals.

There is also lack of a well laid drainage system as the village has open drain pipes through which the wastewater keeps on flowing from the houses.

4.4.2.5 Village Pakhoke

There is lack of public transport in the village so people use their own conveyance for travelling or have to travel a distance of few kilometres to reach the main bus stop. There is lack of drinking water and piped water in the village. Drainage of grey water is also an issue of concern. The village does not have any veterinary dispensary. They have to go to nearby village or have to call the veterinary doctor on special demand to treat the sick cattle. There is also no women and child health care centre available in the village. This village is also not 100% ODF.

4.4.2.6 Village Jaurian Kalan

While surveying the village it was found that this village is not 100% Open Defecation Free (ODF). Majority of the households in the village do not have the toilet facility as no financial help has been provided by the government. Those who possess toilets have been made by the people themselves and belong to middle income group category.

It has been found that the ground water level is quiet raised in this village as around 120 feet good quality of water is available. Due to raised level of groundwater the area exhibits the problem of waterlogging which has affected the agriculture and the crops.

Another issue that is a problem for the villagers is the availability of piped water. Many of the households are still devoid of piped water and they have to fetch water for the daily cores. This supply water is without the facility of reverse osmosis.

The drainage system comprises of open and kaccha drains which give an ugly site to the village and make the environment polluted. The grey water that flows through these drains not only pollute land but water and air also.

There is no bank or ATM in the village and people have a great demand for the same. They have to travel almost 3 to 5 kms to get cash from the bank or ATM.

4.4.2.7 Village Bala Pindi

The road that leads to the village is not an all-weather road hence it becomes very difficult for the villagers to commute especially in rainy season. Piped water supply is also not available in the village and many households are still deprived of this facility.

There is no Primary Health centre or community centre in the village and the nearest is 5 to 10 kilometres away. So, there is an urgent demand of this facility within the village.

Fig. 4.28 Pond on the outskirts

The Anganwadi is also in the nearby village and it becomes difficult for the working women to leave their children at the Anganwadi which is away from their workplace.

The village does not have a proper drainage system. There are open and kaccha drains which flow at various points in the village and carry away the dirty water from the households.

One of the ugly sites of the village is the huge pond on the outskirts of the village which has become a dumping site of the grey water collected from the whole village (Fig. 4.28). The pond is full of algal growth and all kinds of contaminants and pollutants in it. As a result, animals also don’t enter this pond where earlier they used to bathe.

4.4.2.8 Village Thundi

This village of district Gurdaspur lacks in a number of basic facilities and people are living at the mercy of God or the state government. There is no facility of an all-weather road leading to the village. The internal roads are also not cemented or have interlocked tiles. Ill-maintained roads make commuting for the villages difficult especially in the rainy season.

Another basic amenity in which the village lacks is that of piped drinking water. Majority of the people consume water from hand pumps or those who can afford have gone for submersible pumps. This shows that the various centre or state level schemes or for rural development have still not reached certain villages in true letter and spirit.

A Primary Health centre or community health centre as well as a veterinary dispensary are amongst the other non-available facilities in the village. For all kind of medical aid, the villagers have to go to the nearby village.

It is quite pathetic to say that this village does not have a primary school and children walk a few kilometres to get the basic education.

4.4.3 Problems of Villages in District Amritsar

While surveying these villages it was found that there were certain problems which the villagers face.

4.4.3.1 Village Bohlian

The foremost problem of this village is drug- addiction. Majority of the youth and adults are into the habit of intoxication. To meet their daily demand of drugs the youth often steal things from the houses of villagers due to which people feel insecure and cannot keep their belongings unlocked.

Fig. 4.29 Open drains

Another issue of concern is the encroachment of the natural water bodies both by people and by the water weed Eichhornia (Fig.4.29). Both these factors have reduced the size and number of the ponds. Waste water is thrown out of the houses in the open drains making environment dirty and filthy (Fig. 4.30).

Fig. 4.30 Pond with Eichhornia

4.4.3.2 Village Bhindi Aulakh

The village has a pharmacy and dispensary but both are in dilapidated condition. They need a major renovation. There is no proper drainage system in the village (Fig 4.31).

Fig. 4.31 Open Drain (Grey Water)

Since the village is in the immediate vicinity of River Ravi and a lowland so floods washing the area and fields is a frequent problem. The crops get washed away or damaged and compensation by government is insufficient to make for the huge losses which the farmers have to bear.

4.4.3.3 Village Dhanoe Kalan

The village which has a great historic importance and war history is an important tourist attraction. The tourists often visit the village to appreciate the heritage site and war memorial but to their dismay much has not been done by government tourism and archives department for the conservation. The beautiful pond, courtyard etc. of Maharaja Ranjit Singh are not well looked after. The road leading to these tourist destinations is not an all-weather road and need massive repair. The whole village needs a face lift as it an important tourist destination (4.32).

Fig. 4.32 Stubble burning

Fig. 4.33 Pond with scum near tourist spot

There is also an issue of sewage system. The natural open ponds have been converted into a cemented outlet for the collection of filthy water that is a constant source of obnoxious smell and a breeding ground of a number of disease-causing vectors. There is a small old gymnasium which is not much in use because of the fact that it needs a massive face lift and upgradation of equipment. The filthy ditches that are near the ancient courtyard and war memorial put an ugly picture to tourist (Fig.4.33).

4.4.3.4 Village Bhakna Kalan


Fig. 4.34 Drainage tank

Problem of a faulty sewage system: The village had three natural ponds but under certain developmental work, these were converted into open cemented tanks as part of the sewage system (Fig.4.34). The plan was not a success and residents are facing the problem of faulty drainage. The wastewater instead of draining away comes back and overflows which stinks and has become an eye soar. So, the villagers (Fig.4.35) have restored back to the earlier practice of throwing the waste water into an open drain that flows at the periphery of the village.


Fig. 4.35 Interacting with Villagers

Dilapidated Building: Though the village boasts of a high literacy rate with some graduates and a few post-graduates but the village school demands attention from the state authorities. Several reminders have been given by the village panchayat but no heed has been paid to their demand. The boundary wall of the school is broken at several points which puts the security and safety of the school and the students at stake.

Drug menace. Another problem is the prevalent use of drugs by the youth of the village. This is because of the easy availability of the drugs which should be check by the authorities.

4.4.3.5 Village Hetampura

Fig. 4.36 School building

The major issue of the village is Eichhornia weed growing in the ponds. The plant is a menace for the water bodies of the village which are fast shrinking and would gradually disappear if things go unattended.

The facility of public transport is available only from the main road which is a few kilometres away from the village. So, it is not easy for the villagers to commute as they either have to walk or take a lift to reach the main road.

There is also a high demand for an open-air gymnasium for the fitness of the youth that would not only keep them healthy but also drugs at bay.

The building of the High School needs attention as it is not in very good condition (Fig.4.36). Moreover, the school is functioning without a Headmaster and clerical staff since long, making the things worse. The senior most teacher is working very hard and is somehow managing the administrative front.

4.4.3.6 Village Ranian

In this village there is poor development of infrastructure and basic amenities.

Almost all the roads, peripheral as well as internal are un-metalled. The village doesn't boast off an all-weather road. All the roads are kuccha roads. The village has a small middle school which lacks a good infrastructure and has paucity of teachers. The building needs lots of repair and lacks classrooms and good drinking water facilities (Fig. 4.37). Moreover, the teachers frequently get transferred to other places because of the remoteness and inaccessibility of the area.

Fig. 4.37 Drain on the village outskirt

Fig. 4.38 Handpump in school and sanitation

The village being few yards away from the international border, diversification of crops becomes difficult because they pose hindrance from the security point of view. Moreover, due to close proximity to the borders many people have migrated out of the village.

There is lack of street lights and a proper sewage system (Fig. 4.38) as a result of which the wastewater flows through open drains. Only 5% of the village is Open-Defecation Free (ODF) which clearly indicates poor development and untimely availability of government funds.

4.4.4 Problems of villages of District Tarn Taran

4.4.4.1 Village Dall

The village has many basic facilities available but in moderation. There is no bank or ATM available here and villagers have to reach nearest facility which is outside the village. Although the drains are cemented at many places, but still they are open and kuccha which expose the villagers to the risk of air and water borne diseases as well as make the environment and sanitation of the village poor. The village is also not totally open defecation free as many of the households lack the facility of the toilet. There is no facility for the care and health of women and children available in the village.

4.4.4.2 Village Marhi Kamboke

This village of district Tarn Taran is not 100% ODF as many of the houses still do not have the toilet facility. They cannot afford the construction and so far, the government has not provided any financial help for this purpose.

The village has uncovered open pucca drains for the dirty water to flow out of the houses leading to the outskirts of the village.

Availability of piped drinking water is not present in all the households and only 50% of the households have this facility. Rest of the population either uses hand pump or submersible pumps to meet the water requirement.

4.4.4.3 Village Burj

An emerging need of the villagers who mainly practice agriculture is the provision of grain market or mandi. It would become easy for them to sell their agricultural produce in the village itself. Presently they sell it 5 to 6 kilometres away from the village. Having a mandi would not only cut down their expenses but would also save their time and energy which could be utilised for some other productive work.


Fig. 4.39 Dirty water pond

Another issue which the people face is the lack of dispensary both for humans and animals. It becomes difficult in emergency situations to get the first aid for the patient or the animal. Sometimes problems aggravate due to lack of means of transport and commuting.

Drainage of water is a big issue which the villagers want to get resolved (Fig. 4.39). Due to improper drainage the greywater from the houses flows in open but pucca drains.

Drinking water is not available as supply water is not accessible to each household.

Hence the sustainable development goal of providing clean drinking water is still far behind its achievable target**.**

4.4.4.4 Village Manakpur

The village has no dispensary and there is lack of many basic amenities like drinking water, drainage system etc. The village is not 100% ODF (SGD-6) as only 30-35% have access to the toilet facility. Water drainage is another problem faced by the villagers. Facility of drinking water is also not available hence people get their own bore wells done to get clean drinking water.

Crop irrigation has become difficult due to the fact that underground canal system laid down in the fields by irrigation department are out of order and the traditional method of irrigation through dug up canals (khals) have been cemented, has not been a good solution to the problem.

Drug addiction is also quite prevalent in the village. This probably is due to illegal drug trafficking across the border. The youth of this district have ruined their life and property to the addiction of drugs.

4.4.4.5 Village Kalia

There is no veterinary hospital or dispensary for the care of animals. People have to take their sick animals to the nearby dispensary or they have to call the doctor on special request to the village.

The facility of drinking water has still not reached the masses and about 80% of the population has the facility and 20% are still devoid of it.

There is no community centre or Panchayat Bhawan that could be used for the common activities by all the villagers. Hence to hold local functions becomes a little expensive and difficult.

4.4.4.6 Village Wan Tara Singh

The road leading to the village is in bad shape and the internal roads are not cemented or with interlocking tiles. There is an urgent need of repair and carpeting of the roads so that commuting by the villagers becomes hassle free.

There is also lack of public transport and people have to use their own means of conveyance for travelling, adding an extra burden on their pockets.

A long-standing demand of a veterinary hospital or dispensary in the village has been there. Under such circumstances taking care of sick animals becomes a little difficult for the villagers.

4.4.5 Problems of villages of District Ferozepur

4.4.5.1 Village Bare ke

The village has an issue of drainage of water. The provision available in this regard is faulty because the dirty water often over flows and make the surroundings dirty, filthy with lots of obnoxious smell (Fig. 4.40). Moreover, it is also a site or breeding ground for vectors of water borne diseases thus posing a risk to the health and sanitation of the village as well as villagers.

Fig. 4.40 Dirty water and weeds in pond

The village has a dispensary of its own but it doesn't have an ANM or a lady doctor to deal with the health issues of female patients.

There is also a strong demand of a veterinary centre/dispensary for the medical aid of animals of the village. Lack of the same poses inconvenience to the cattle owners because the nearest facility is 3-5 km away in the nearby village.

There is no community hall in the village where people can hold community functions/ celebrations or sometimes for personal functions. So, it is one of the much-needed basic amenity.

It was found that the village has a Gymnasium but the sorry state of affairs was that it is without any equipment. Thus, having only the building is of little use to the local people.

4.4.5.2 Village Jhuggee Hazara

In this village there is no availability of a dispensary/PHC and patients have to go to nearby village. It is very difficult in case of emergency when bad road conditions and commuting facilitates are not favourable (Fig. 4.41).

Fig. 4.41 Bad roads & filth

Things are more pathic when the facility is extended to the villagers but only partial. It is mentioned here that availability of veterinary dispensary in the village is without doctors.

As Punjab is the state of five rivers and three of them flow across the Indian Punjab. One of these is River Sutlej. This village is in the vicinity of this river and is a low-lying area. Hence whenever the river overflows it brings the nearby areas and this village into the flood situation. This leads to flooding of the crop laden fields and eventually damage the crops. So, toiling of the farmers throughout the year goes waste in a short time devastating their crops.

Moreover, being in near proximity of border fence is a great disadvantage. All kinds of basic facilities cannot be reached to such destinations hence the locals are deprived of many welfare programmes and benefits.

One of the major problem of the people is that they have been cultivating the land since generations but they are not the registered legal owners of the land. The piece of land they had been toiling hard is not their registered property as per the revenue department of the district. Several reminders by the villagers to the government authorities have fallen on deaf ears. Similarly, there is reservation of Border area in various government jobs but due to ignorance of legal facts, the actual beneficiaries remain deprived and others get the benefit by manipulating and misuse the facilities.

Another problem faced by the villagers is improper drainage system. The waste water from the houses flows through open drains which are not cemented at many points so the grey water keeps overflowing and polluting the air, soil and ground water.

4.4.5.3 Village Jhugge Shillian

The village has no sewage system for drainage of waste water. The drains are open and kuccha where grey water often overflows on the internal roads especially during rainy season. The major part of the village wears a very unhygienic look and poses a danger to the environmental sanitation.

Fig. 4.42 Un-hygienic conditions

The village is still marching towards the goal of making ODF India. It is about 50% of the households in the village that have the facility of toilets and rest of the households are struggling towards this goal.

Only the road leading to the village is an all-season road, rest all internal roads are kuccha. All the roads are in bad shape and need repair (Fig. 4.42).

Another basic amenity i.e. facility of drinking water is also not up to the mark. Untreated drinking water is available and the overhead tanks for the storage of water are not maintained properly making the water more unfit for drinking.

4.4.5.4 Village Karman

Though the village is quite well equipped with basic amenities and reflects prosperity but at the same time people are facing the problem of immigration of students to foreign land, may be for study purpose or better job opportunities. The overall environment is unhygienic with waste dumped at places (Fig.4.43)

Fig. 4.43 Open dumping of waste

River Sutlej which is a source of irrigation for the fields, flows near the vicinity of the village. During rainy season people often complain of some kind of effluent discharged into the water body. This makes the water highly unfit for irrigation purpose and unpleasant smell continuously diffuses in the air. This issue has been raised several times by the villagers to the higher authorities but no heed has been paid. It can become a cause of many serious ailments which might at this point go unnoticed.

The villagers have a great demand for gymnasium. They have identified the site but nothing has been done by the concerned authorities for its construction. They are very keen to have this facility for the young boys and girls of the village so that they spend quality time rather than wasting their time and energy in loitering or hooked up to mobile phones.

4.4.5.5 Village Ruhela Haji

One of the most challenging issues is the non-availability of piped supply water. Most of the people are dependent on handpump to meet their water requirement. This water is full of many kinds of impurities and pollutants.

Another issue which needs to be mentioned is the non-availability of primary health centre or a dispensary. At times of emergency, the villagers have to rush to the nearest available facility which is 5-10 kms away. The village also lacks a veterinary dispensary and with hurdles like ill-maintained roads, lack of means of transport, it is difficult to carry the sick animals.

The village is not 100% ODF as majority of the households lack the toilet facility. The households which have the toilets have septic tanks. Drainage system is not properly laid and the village showcases open pucca drains covered with slabs. The village has a middle school which has paucity of teachers and there is one school in the nearby village. There is an urgent demand of a community centre in the village where people can gather and hold religious as well as non-religious functions. If it is difficult to open a bank branch in the village at least an ATM should be available so that in case of emergency the villagers don’t have to rush to the nearest facility which is 5kms away.

4.4.5.6 Village Mamdot Hittar

The village lacks a proper sewage system as waste water flows into a nearby common drain. This open drain is a constant source of filth and pollution as well as a site of water borne infections and diseases.

The village has an all-weather main road with pucca internal roads. These roads are in poor state due to lack of repair and maintenance since long. There is one natural pond in the village but is now converted into a sewage collecting ditch (Fig.4.44).


Fig. 4.44 Open drain

4.4.6 Problems of Villages of District Fazilka

4.4.6.1 Village Asaf wala

Though the village is situated near the Sadiqui-Suleman border which is quiet a tourist attraction but the visit to the village shows no such influence. There is poor availability of drinking water facility with only 50% of the population availing the facility. Even those who possess the facility enjoy it under poor sanitation and maintenance (Fig.4.45). Areas from where drinking water is used possess a lot of algal & fungal growth and stagnant water which is a constant source of infection and a possible cause of outbreak of water borne diseases. This thus puts the life of inhabitants especially children at risk.


Fig. 4.45 Poor sanitation

Another issue which was reported by the people and also evident on visiting the village was poor drainage and waste disposal. The waste water from houses flows in open drains. The whole village is traversed with these drains and filthy water flowing and sometimes overflowing through them. The waste and garbage collected from houses are simply dumped outside or near the boundary of the houses. Hence another ugly site for the visitors and reflects the lack of environmental awareness and consciousness among the visitors.

The village has a middle level school, the only source of basic education to the children. But it demands repair and upgradation of classrooms. The school needs proper maintenance of the building and other available facilities.

4.4.6.2 Village Muhar Jamsher

This village is a special village because of its unique location and this uniqueness has been a great source of hindrance. The village is totally cut off from the rest of the nation as it has barbed wire fence on three sides – on these sides it is Pakistan border and on fourth side its river Sutlej and Indian fencing.

Fig. 4.46 Solid waste Dump

Before 2015 the village was connected with the country by a pontoon bridge but now the village has a bridge for better and easy commuting. At many places heaps of solid waste can be seen dumped making the environment ugly and unhealthy (Fig. 4.46). The village is still not easily accessible because of BSF check-post and security checks at the village gate. Hence the villagers are landlocked in their own country even after 76 years of independence.

Due to such difficult accessibility brides from other villages don’t prefer getting married in this village. There is also lack of public transport facility in this hamlet which makes commuting difficult and thus posing as another hindrance towards accessibility.

Moreover, there is poor quality of water and no supply of drinking water is available. Thus, residents use submersible pumps to use the water for various purposes.

4.2.6.3 Village Ariyan Wala

Fig. 4.47 Eichhornia in pond

The village has a poor drainage and no proper sewage system is available. The waste water flows in open drains which are though pucca but uncovered. Hence the bad smell and dirty water makes an ugly site in the village (Fig. 4.47). There are no natural ponds available for rain water harvesting because they have been converted into waste water tanks. The primary school needs repair of the walls and majority of the houses are without piped water connection.

The village lacks a community hall which people can use for a common purpose. Moreover, there is no primary health centre or dispensary in the village and in case of emergency they have to rush to the nearby village. Even there is lack of a bank/ATM facility and villagers sometimes find it difficult to get cash in urgency.

4.2.6.4 Village Dhandi Qadim

The village has a very small dispensary or Primary health centre and it is in very poor condition so upgradation of the same is demand of the villagers.

Septic tanks/ponds are a source of filth and pollution of land and water (Fig. 4.48). Open drains for the disposal of waste water are seen. A natural pond on the outskirts of the village has been made a place for dumping the waste water of the village.

Fig. 4.48 Ponds with scum

Various the problems/issues of the villages of the study area have been summed up in table 4.34 and Fig. 4.49.

Table 4.34: Problems/issues in various the selected Border villages of Punjab

S.No.	Problems/issues	No. of villages	% of villages
1	Poor drainage	10	29.41
2	Poor roads	9	26.50
3	Dispensary	13	38.23
4	Piped drinking water	13	38.23
5	Ponds converted to sewage sinks	5	14.70
6	ODF	6	17.6
7	Issues related to schools	8	23.53
8	Drugs	3	8.82
9	Floods	2	5.88
10	Anganwadi	3	8.82
11	Bank/ATM	5	14.70
12	sewage	34	100
13	compensation	12	35
14	Community hall	6	17.6
15	Water logging	4	11.76

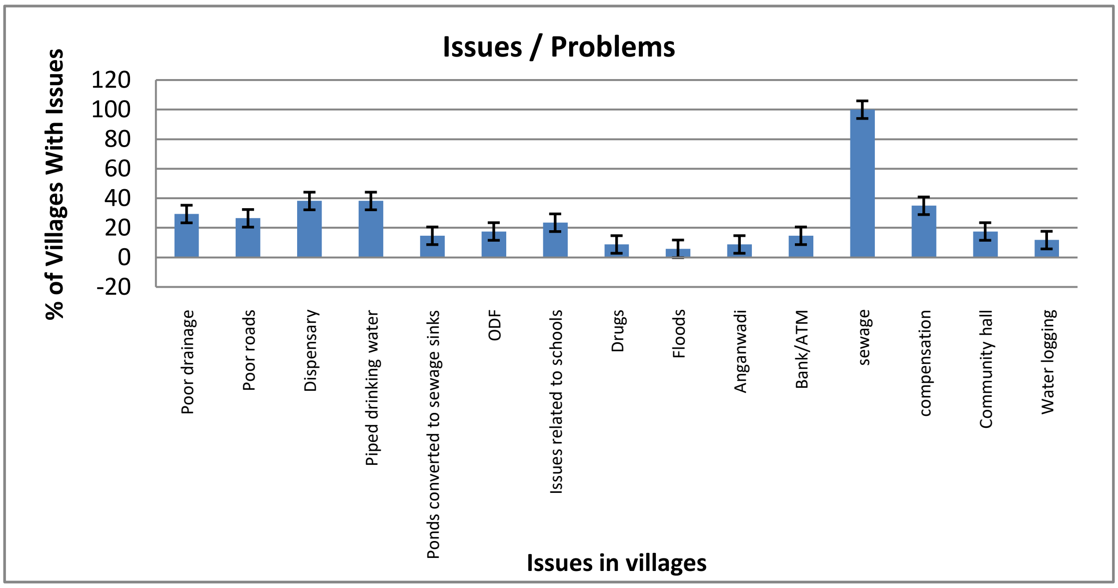


Fig. 4.49: Problems/issues in the selected Border villages of Punjab

4.4.7 Demands of the villagers

While surveying the villages and interacting with the villagers, it was found that some of the challenges and issues which the villagers face, they are in a way the demand of the villagers. These have been put in a tabulated in the following (Table 4.35).

Table 4.35: Demands of the individuals in the selected border districts of Punjab

S.No.	Demand	Districts						Total no. of individuals
		Amritsar	Fazilka	Ferozepur	Gurdaspur	Pathankot	Tarn Taran	
1	Approach roads to *Deras*	12	4	6	9	2	5	38
2	Community hall	14	9	13	15	8	11	70
4	Drainage	70	50	75	104	43	76	418
5	Drains& streets	76	45	45	97	45	84	392
6	Degree college	20	2	6	15	0	4	47
7	SSC schools	25	0	7	18	4	10	64
8	Repair& Upgradation of schools	34	4	0	12	8	19	77
9	Hospital/Dispensary	55	40	30	32	9	56	222
10	Vet. Dispensary	32	22	18	24	28	45	169
11	Piped water supply	10	43	46	54	38	43	234
12	Toilets	10	15	12	28	20	22	107
13	Street lights	45	22	26	38	33	57	221
14	Sports facilities	12	7	17	28	3	46	113
15	Incubation centres	14	8	16	19	15	28	100
	Total	**429**	**271**	**305**	**465**	**236**	**484**	**2272**

Objective 4: Evaluation of villages based on development and development schemes.

4.5 Evaluation of villages under study

4.5.1 Evaluation on the basis of development indicators

The villages that were randomly selected were surveyed. To evaluate the villages on the basis of development, the following parameters were taken as indicators of development.

Keeping in mind the SAGY scheme, the Centre and State Government has been launching various Flagship schemes for rural development in order to make the villages self-reliant. The aim has been to provide or make available the basic amenities needed to lead a good life. There are a number of schemes for rural development but only two development schemes i.e. Border Area Development Programme (BADP) and Swachh Bharat Mission (SBM) have been taken into consideration.

For this purpose, these two schemes have been reviewed for the period of five years. The annual allotment of funds as well as the actual & effective implementation of the scheme as per the target set by the concerned department have been taken up. The details of the funds under these schemes have been taken from the Department of Development and planning, Punjab and the SBM portal as well as from the district administration. All the data collected from various official sources is from the year 2015-16 to 2019-2020.

The villages chosen for study from the 17 border blocks of the border districts were surveyed and the people were randomly interviewed. Upon survey a large number of indicators were found common in all the villages. These common indicators were selected for evaluation of the villages and their development status based on the three-point scale as mentioned in the Chapter of Materials & Methods in Table no. 3.11. The data collected has been put in the form of tables (4.36-4.41) as represented below:

Table 4.36: Status of Villages of Pathankot on the Basis of Development Indicators

🟩 **YES** 🟨 **NEARBY** 🟥 NO

S. No.	Indicators/Parameters	VILLAGES			
		Khojke Chak	**Dhinda**	**Paharipur**	**Datyal**
1	Grain market	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴
2	Ground water for Irrigation	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴
3	Milk cooperative	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴
4	Rural housing	🟢 ⚪ ⚪	🟢 ⚪ ⚪	🟢 ⚪ ⚪	🟢 ⚪ ⚪
5	Drinking water	🟢 ⚪ ⚪	🟢 ⚪ ⚪	🟢 ⚪ ⚪	🟢 ⚪ ⚪
6	Piped Water supply	⚪ 🟡 ⚪	⚪ 🟡 ⚪	⚪ 🟡 ⚪	⚪ 🟡 ⚪
7	Roads	🟢 ⚪ ⚪	🟢 ⚪ ⚪	🟢 ⚪ ⚪	🟢 ⚪ ⚪
8	Rural electrification	🟢 ⚪ ⚪	🟢 ⚪ ⚪	🟢 ⚪ ⚪	🟢 ⚪ ⚪
9	Non-conventional Energy	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴
10	Community hall	🟢 ⚪ ⚪	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴
11	Sports activities	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴	⚪ ⚪ 🔴
12	Bank/ATM	⚪ 🟡 ⚪	⚪ 🟡 ⚪	⚪ 🟡 ⚪	⚪ 🟡 ⚪
13	Public Distribution system	⚪ 🟡 ⚪	⚪ 🟡 ⚪	⚪ 🟡 ⚪	⚪ 🟡 ⚪
14	Drainage & Sewage system	⚪ 🟡 ⚪	⚪ 🟡 ⚪	⚪ 🟡 ⚪	⚪ 🟡 ⚪

S. No.	Indicators/Parameters	VILLAGES			
		Khojke Chak	**Dhinda**	**Paharipur**	**Datyal**
15	Veterinary hospital	○🟡○	○🟡○	○🟡○	○🟡○
16	Primary Health Centre/Dispensary	🟢○○	○🟡○	○🟡○	○🟡○
17	Women & Child Care Centre	○○🔴	○○🔴	○○🔴	○○🔴
18	Transportation facility	○🟡○	○🟡○	○🟡○	○🟡○
19	Water management and efficiency	○○🔴	○○🔴	○○🔴	○○🔴
20	Telecommunication & internet	🟢○○	🟢○○	🟢○○	🟢○○
21	ODF	○○🔴	○○🔴	○○🔴	○○🔴
	Score/Grade*	**7 (C)**	**5 (C)**	**5 (C)**	**5 (C)**

**Materials and Methods (Table 3.12)*

From the above table (Table 4.36) it is clear the at out of the 21 indicators (33%) of them are available at the distance of 2 to 5 kilometres and (26%) of them are present in the villages. Almost 42% of the parameter/ indicators are available at a distance of 5 to 10 kms or they are not available in the near vicinity. On the basis of the above results the villages of District Pathankot can be graded as follows:

Khojke Chak> Dhinda= Paharipur= Datyal

Table 4.37: Status of Villages of Gurdaspur on the Basis of Development Indicators

🟩 **YES** 🟨 **NEARBY** 🟥 NO

S. No.	Indicators/Parameters	Villages							
		Dostpur	**Gadi Kalan**	**Jaurian Kalan**	**Pakhoke**	**Nadala**	**Thundi**	**Bharth Qazi Chak**	**Bala Pindi**
1	Grain market	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴
2	Ground water for Irrigation	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
3	Milk cooperative	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴
4	Rural housing	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○
5	Drinking water	○ 🟡 ○	○ ○ 🔴	○ 🟡 ○	○ 🟡 ○	○ 🟡 ○	○ ○ 🔴	○ 🟡 ○	○ ○ 🔴
6	Piped Water supply	○ 🟡 ○	○ 🟡 ○	○ 🟡 ○	○ 🟡 ○	○ 🟡 ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
7	Roads	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ 🟡 ○	○ 🟡 ○
8	Rural electrification	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
9	Non-conventional Energy	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
10	Community hall	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○
11	Sports activities	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
12	Bank/ATM	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ 🟡 ○
13	PDS	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ 🟡 ○
14	Drainage & Sewage system	○ 🟡 ○	○ 🟡 ○	○ 🟡 ○	○ 🟡 ○	○ 🟡 ○	○ 🟡 ○	○ 🟡 ○	○ ○ 🔴
15	Veterinary hospital	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴

S. No.	**Indicators/Parameters**	**Villages**							
		Dostpur	**Gadi Kalan**	**Jaurian Kalan**	**Pakhoke**	**Nadala**	**Thundi**	**Bharth Qazi Chak**	**Bala Pindi**
16	PHC/Dispensary	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴
17	Women & Child Care Centre	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ 🟡 ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
18	Transportation facility	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴
19	Rain water harvesting	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
20	Telecommunication& internet	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
21	ODF	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
	Score / Grade*	**13 (B)**	**14 (A)**	**15 (A)**	**9 (B)**	**4 (C)**	**1 (C)**	**8 (B)**	**4 (C)**

**Materials and Methods (Table 3.12)*

In district Gurdaspur 65% of the development indicators are available in the villages (38%) under study (Table 4.37). About 13% of the indicators are available to the villagers within the distance of 2 to 5 kilometres while 66% of the indicators are not available in the villages (38%) and people have to travel almost 5 to 10 kilometres to reach those facilities. The six villages that were surveyed villages Gadi Kalan and Jaurian Kalan are the most developed (A grade) followed by Dostpur and Pakhoke. Villages Nadala, Thundi and Bala Pindi (C Grade) were the least developed ones. On the basis of the above results the villages of District Gurdaspur can be graded as follows:

Gadi kalan>Jaurian kalan>Dostpur.Pakhoke>Bhatath Qazi Chak> Balapindi/Nadala>Thundi

Table 4.38: Status of Villages of Amritsar on the Basis of Development Indicators

🟩 **YES** 🟨 **NEARBY** 🟥 NO

S.No.	Indicators/Parameters	Villages					
		Bhakna Kalan	**Dhanoe Kalan**	**Hetampura**	**Ranian**	**Bhindi Aulakh**	**Bohlian**
1	Grain market	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ 🟡 ○
2	Ground water for Irrigation	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴
3	Milk cooperative	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
4	Rural housing	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
5	Drinking water	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
6	Piped Water supply	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
7	Roads	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
8	Rural electrification	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
9	Non-conventional Energy	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
10	Community hall	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○
11	Sports activities	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴
12	Bank/ATM	🟢 ○ ○	○ ○ 🔴	○ 🟡 ○	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○
13	PDS	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○
14	Drainage & Sewage system	○ ○ 🔴	○ 🟡 ○	○ 🟡 ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
15	Veterinary hospital	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴

S.No.	Indicators/Parameters	Villages					
		Bhakna Kalan	**Dhanoe Kalan**	**Hetampura**	**Ranian**	**Bhindi Aulakh**	**Bohlian**
16	PHC/Dispensary	🟢○○	🟢○○	○○🔴	○○🔴	○○🔴	🟢○○
17	Women & Child Care Centre	🟢○○	○○🔴	○○🔴	○○🔴	○○🔴	○○🔴
18	Transportation facility	🟢○○	○○🔴	○○🔴	○○🔴	🟢○○	🟢○○
19	Water management and efficiency	○○🔴	○○🔴	○○🔴	○○🔴	○○🔴	○○🔴
20	Telecommunication& internet	🟢○○	🟢○○	○○🔴	○○🔴	🟢○○	🟢○○
21	ODF	🟢○○	○○🔴	○○🔴	○○🔴	○○🔴	🟢○○
	Score/Grade	**18 (A)**	**10 (B)**	**8(B)**	**7 (B)**	**12 (B)**	**13 (B)**

**Materials and Methods (Table 3.12)*

Table 4.38 represents the evaluation status of villages of district Amritsar on the basis of availability of development indicators. 54% of the indicators are available within the villages whereas 43% of the development indicators are far away from the villages and people have to travel 5 to 10 kilometres to reach those facility /indicators. 3% of the development indicators are available within a distance of 2 to 5 kms. On the basis of the above results the villages of District Amritsar can be graded as follows:

Bhakna Kalan > Bohlian > Bhindian Aulakh > Dhanoe Kalan > Hetampura > Ranian

Table 4.39: Status of Villages of Tarn Taran on the Basis of Development Indicators

🟩 **YES** 🟨 **NEARBY** 🟥 NO

S. No.	**Indicator/Parameters**	**Villages**					
		Kalia	**Mari Kamboke**	**Burj**	**Manakpur**	**Dall**	**Wan Tara Singh**
1	Grain market	🟢○○	○○🔴	○○🔴	○○🔴	○○🔴	○○🔴
2	Ground water for Irrigation	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○
3	Milk cooperative	🟢○○	🟢○○	○○🔴	○○🔴	○○🔴	🟢○○
4	Rural housing	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○
5	Drinking water	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○
6	Piped Water supply	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○
7	Roads	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○
8	Rural electrification	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○
9	Non-conventional Energy	○○🔴	○○🔴	○○🔴	○○🔴	○○🔴	○○🔴
10	Community hall	🟢○○	🟢○○	○○🔴	🟢○○	🟢○○	○○🔴
11	Sports activities	🟢○○	🟢○○	○○🔴	○○🔴	🟢○○	🟢○○
12	Bank/ATM	🟢○○	🟢○○	🟢○○	○○🔴	○○🔴	○○🔴
13	PDS	🟢○○	🟢○○	○○🔴	○○🔴	○○🔴	○○🔴
14	Drainage & Sewage system	○🟡○	○🟡○	○🟡○	○🟡○	○🟡○	○🟡○
15	Veterinary hospital	🟢○○	🟢○○	○🟡○	○🟡○	🟢○○	○🟡○

S. No.	**Indicator/Parameters**	**Villages**					
		Kalia	**Mari Kamboke**	**Burj**	**Manakpur**	**Dall**	**Wan Tara Singh**
16	PHC/Dispensary	🟢○○	○🟡○	🟢○○	○🟡○	🟢○○	○🟡○
17	Women & Child Care Centre	🟢○○	🟢○○	○🟡○	○🟡○	○🟡○	○🟡○
18	Transportation facility	🟢○○	○🟡○	○🟡○	○🟡○	🟢○○	🟢○○
19	Water management and efficiency	○○🔴	○○🔴	○○🔴	○○🔴	○○🔴	○○🔴
20	Telecommunication & internet	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○
21	ODF	🟢○○	○○🔴	○○🔴	○○🔴	○○🔴	○○🔴
	Score/Grade*	**18 (A)**	**14 (B)**	**9 (B)**	**8 (B)**	**12 (B)**	**10 (B)**

**Materials and Methods (Table 3.12)*

Table 4.39 shows the status of 6 different villages of district Tarn Taran. It is very evident that more than 50% of the villages under study are quite self-sufficient in having majority (69%) of the development indicators in the villages themselves. For a few of the indicators the villagers have to travel for a distance of 2 to 5 kms (50%) and another few (38%) availabilities are at a distance range of 5 to 10 kilometres or they are completely not available in the village. On the basis of the above results the villages of District Tarn Taran can be graded as follows:

Kalia> Marhi Kamboke> Dall> Wan Tara Singh> Burj>Manakpur

Table 4.40: Status of Villages of Ferozepur on the Basis of Development Indicators

🟩 **YES** 🟨 **NEARBY** 🟥 NO

S.No.	**Indicators/Parameters**	**Villages**					
		Bare ke	**Hazara**	**Mamdot hittar**	**Karman**	**Ruhela Haji**	**Jhugge Shillian**
1	Grain market	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴
2	Ground water for Irrigation	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
3	Milk cooperative	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○
4	Rural housing	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
5	Drinking water	○ 🟡 ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ 🟡 ○
6	Piped Water supply	○ 🟡 ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ 🟡 ○
7	Roads	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
8	Rural electrification	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
9	Non-conventional Energy	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
10	Community hall	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴
11	Sports activities	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○
12	Bank/ATM	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
13	PDS	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○
14	Drainage & Sewage system	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ 🟡 ○	○ ○ 🔴
15	Veterinary hospital	○ ○ 🔴	○ ○ 🔴	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴

S.No.	Indicators/Parameters	Villages					
		Bare ke	**Hazara**	**Mamdot hittar**	**Karman**	**Ruhela Haji**	**Jhugge Shillian**
16	PHC/Dispensary	🟢○○	○○🔴	🟢○○	🟢○○	○○🔴	○○🔴
17	Women & Child Care Centre	○○🔴	○○🔴	🟢○○	🟢○○	○○🔴	○○🔴
18	Transportation facility	🟢○○	○○🔴	🟢○○	🟢○○	○○🔴	🟢○○
19	Rain water harvesting	○○🔴	○○🔴	○○🔴	🟢○○	○○🔴	○○🔴
20	Telecommunication& internet	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○	🟢○○
21	ODF	○🟡○	🟢○○	🟢○○	○🟡○	○○🔴	🟢○○
	Score/Grade*	**13 (B)**	**8 (B)**	**17 (A)**	**17 (A)**	**9 (B)**	**11 (B)**

**Materials and Methods (Table 3.12)*

Table 4.40 represents the indicator availability in the villages under study of District Ferozepur. It has been found that 35% of the indicators are not available in the village and people have to travel a distance of 5 to 10 kms to avail these indicators. Another 69% of the indicators are available in the majority (50%) of the villages surveyed. Only a small percentage (5%) of the development indicators are available at a distance of 2 to 5 kms. On the basis of the above results the villages of District Ferozepur can be graded as follows:

Mamdot Hithar=Karman> Bare ke>Jhuggee Shillian>Rohela Haji> Hazara.

Table 4.41: Status of Villages of District Fazilka on the Basis of Development Indicators

🟩 **YES** 🟨 **NEARBY** 🟥 NO

S.No.	**Indicators/Parameters**	**Villages**			
		Dhandi Qadim	**Asafwala**	**Araianwala**	**Muhar Jamsher**
1	Grain market	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
2	Ground water for Irrigation	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
3	Milk cooperative	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴
4	Rural housing	○ ○ 🔴	○ 🟡 ○	○ 🟡 ○	○ ○ 🔴
5	Drinking water	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴
6	Piped Water supply	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴
7	Roads	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴
8	Rural electrification	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○
9	Non-conventional Energy	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
10	Community hall	🟢 ○ ○	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴
11	Sports activities	🟢 ○ ○	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴
12	Bank/ATM	○ 🟡 ○	🟢 ○ ○	○ 🟡 ○	○ ○ 🔴
13	PDS	○ ○ 🔴	🟢 ○ ○	○ ○ 🔴	○ ○ 🔴
14	Drainage & Sewage system	○ 🟡 ○	○ ○ 🔴	○ ○ 🔴	○ ○ 🔴
15	Veterinary hospital	🟢 ○ ○	○ ○ 🔴	○ 🟡 ○	○ ○ 🔴

S.No.	**Indicators/Parameters**	**Villages**			
		Dhandi Qadim	**Asafwala**	**Araianwala**	**Muhar Jamsher**
16	PHC/Dispensary	🟢○○	○○🔴	○🟡○	○○🔴
17	Women & Child Care Centre	○○🔴	○○🔴	○🟡○	○○🔴
18	Transportation facility	○○🔴	🟢○○	○○🔴	○○🔴
19	Rain Water harvesting	○○🔴	○○🔴	○○🔴	○○🔴
20	Telecommunication& internet	🟢○○	🟢○○	🟢○○	○○🔴
21	ODF	🟢○○	○○🔴	○🟡○	○○🔴
	Score/Grade*	**11 (B)**	**12 (B)**	**7 (C)**	**2 (C)**

**Materials and Methods (Table 3.12)*

Table 4.41 represents the development status of the villages that were visited during the study in the border district of Fazilka. 55% of the development indicators are available in the villages whereas 38% of the indicators are not available within the villages and people travel 5 to 10 kilometres to get those facilities. 7% of the indicators are available at distance of 2 to 5 kms or the availability is neither inadequate nor sufficient within the village itself. Development wise the villages are in the following order:

Asafwala> Dhinda Qadim>Ariyanwala>Muhar Jamsher. The overall development status of the villages surveyed in the six districts are shown in Fig. 4.50.

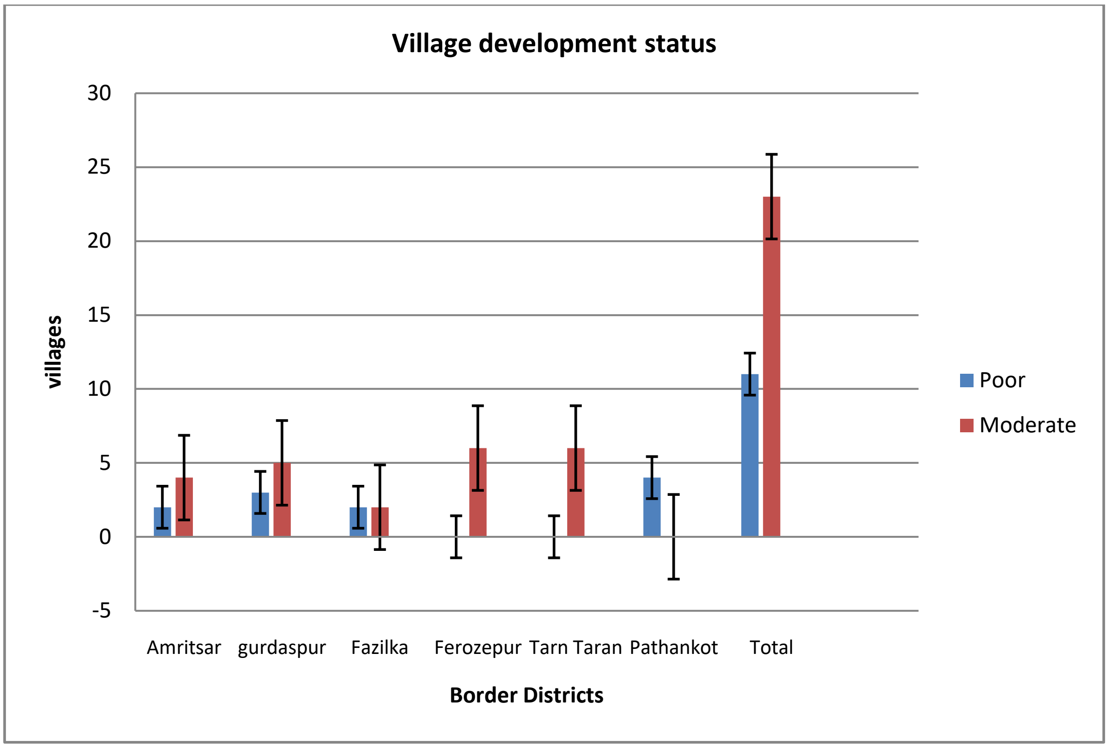


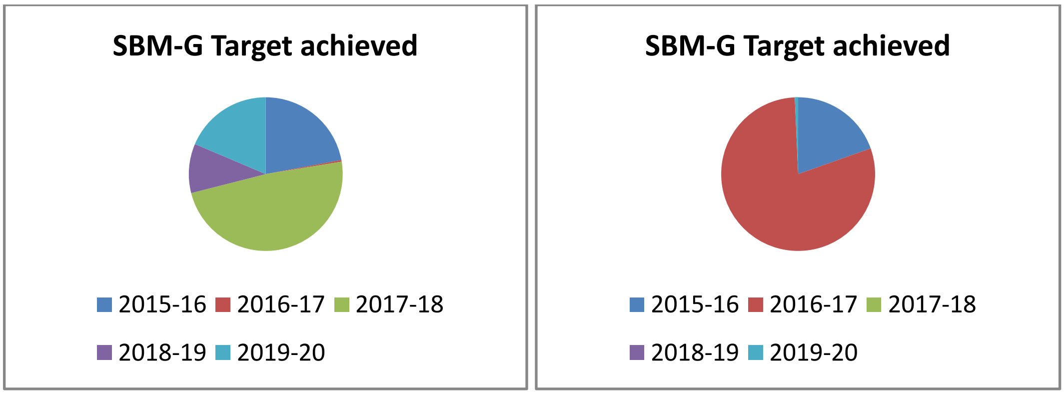
Fig. 4.50: Development status of villages surveyed in the border districts of Punjab

4.5.2 Evaluation on the basis of Rural Development Schemes

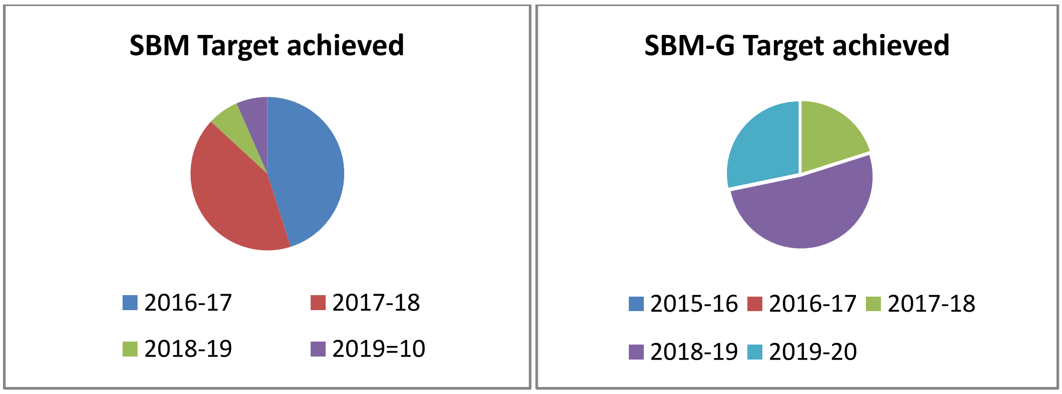
4.5.2.1 Swachh Bharat Mission-Gramin (SBM-G)

The status, implementation and evaluation of SBM (G) Phase II, the national Flagship scheme/mission for sanitation and cleanliness in rural areas was carried out in all the six border districts and the results are shown in fig. 4.51 (a-c) and the same is depicted in fig. 4.52.

a) District Pathankot and Gurdaspur



b) District Amritsar and Tarn Taran



c) District Ferozepur and Fazilka

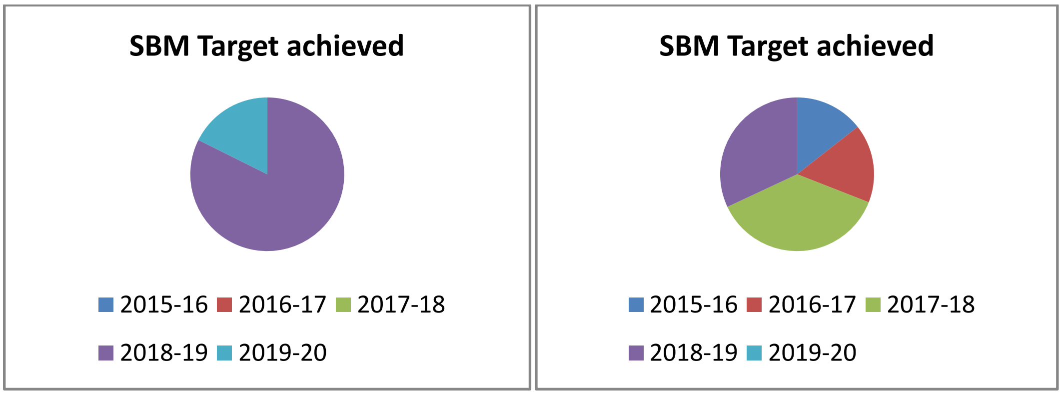


Fig. 4.51 (a to c): Swachh Bharat Mission Target achieved from year 2015-2020* of the selected border districts of Punjab.

*Source: https://sbm.gov.in › Secure › Entry › User Menu

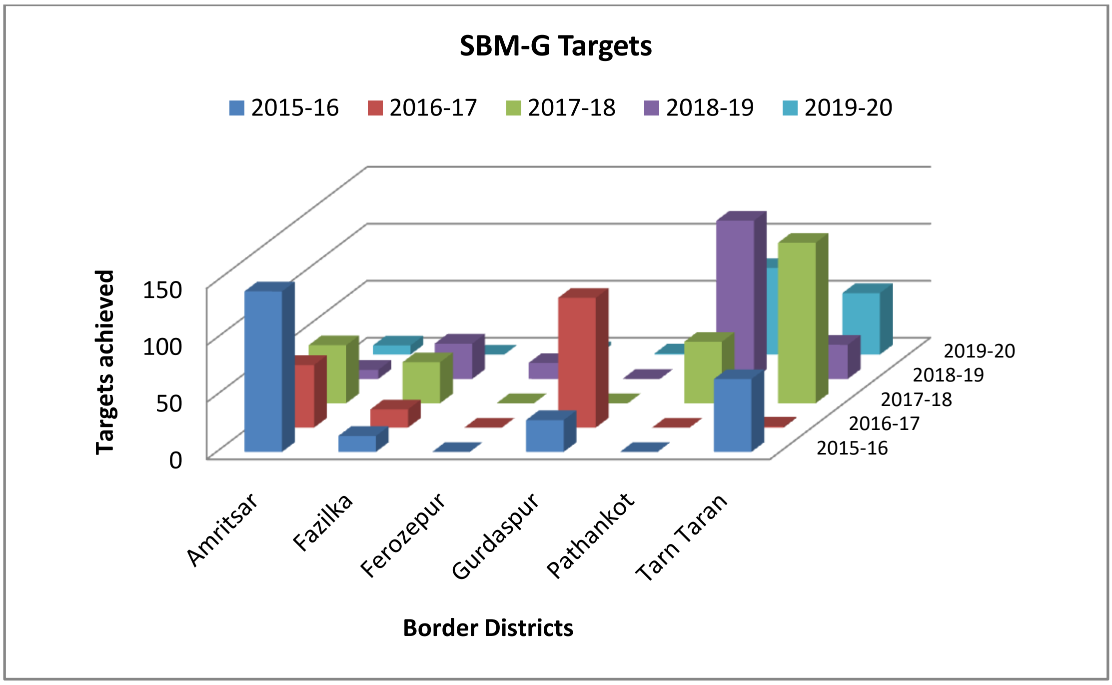


Fig. 4.52: District-wise SBM-G Targets achieved in the selected Border Districts from year 2015-2020.

The ODF score of the selected border districts as shown in Table 4.42 & Fig. 4.53 reveals that the delta achievement score as given by the concerned government department is highest in district Gurdaspur (29.69) followed by district Fazilka (15.47) and district Amritsar (14.56). These districts fall in the category of aspirants as per the norms of Swachh Bharat Mission (G).

Table 4.42: District-wise ODF score (Delta achievement score) *

S.No.	District	Baseline odf+ score	Current ODF+ SCORE	Delta Achievement	Category
1	Pathankot	1.79	5.06	9.99	*-do-
2	Gurdaspur	1.79	11.51	29.69	*-do-
3	Amritsar	0.69	5.51	14.56	*Aspirants
4	Tarn Taran	0.55	4.34	11.43	*-do-
5	Ferozepur	0.47	4.04	10.76	*-do-
6	Fazilka	0.74	5.82	15.47	*-do-

*Source: https://sbm.gov.in › SSG2023 › ODFPLusRanking (Aug.,2023

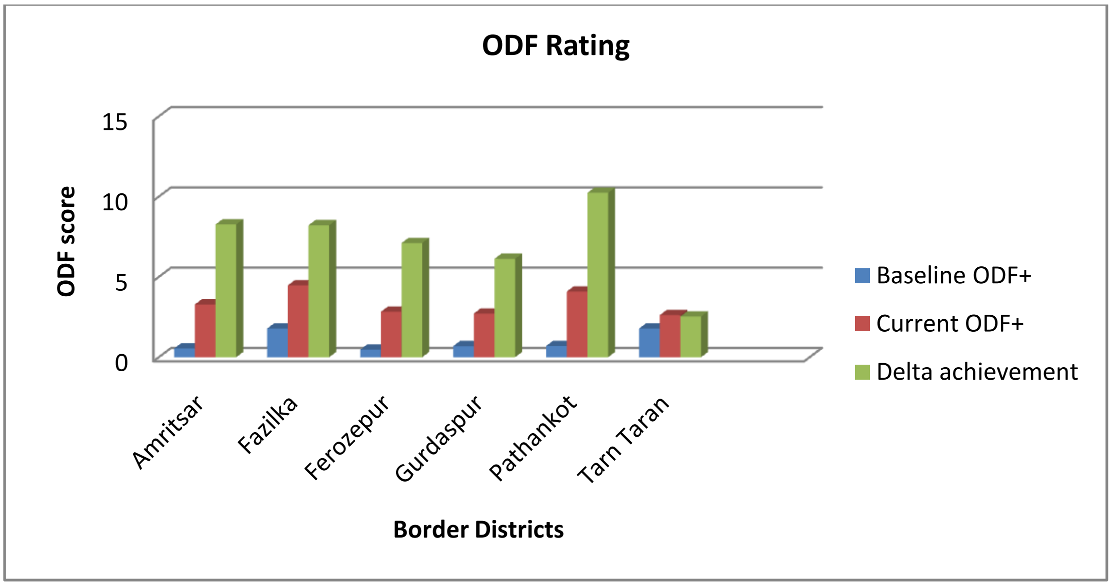


Fig 4.53: District-wise ODF score (Delta achievement score)

Table 4.43 shows that all the gram panchayats (GP) have under gone through the process of baseline survey as part of the Swachh Bharat Mission (G) programme. This survey is the preliminary part of this mission and helps in collection of basic data that later on helps in assessing the details pertaining to the sanitation, health and clean environment and ODF status. Accordingly, the various parameters of the flagship programme are implemented in the villages.

Table 4.43: District-wise Status of Village Self - Assessment *

S.No.	District	Total GP	Baseline self-assessment	Latest self-assessment	Total Villages	Pending
1	Pathankot	421	421	474	474	-
2	Gurdaspur	1285	1285	1347	1347	-
3	Amritsar	859	859	859	882	23
4	Tarn Taran	575	575	608	608	-
5	Ferozepur	836	836	891	891	55
6	Fazilka	434	434	434	440	6

**Source: SBM website*

4.5.2.2 Border Area Development Scheme (BADP)

The impact and implementation of Border Area Development Programme which is a centrally sponsored non lapsable fund scheme was also evaluated under this scheme all the border districts are allocated a certain amount of funds which are utilised for various infrastructural developmental activities the programme was investigated from the year 2015-16 to 2019-20 and the results have been shown in Table 4.4 below:

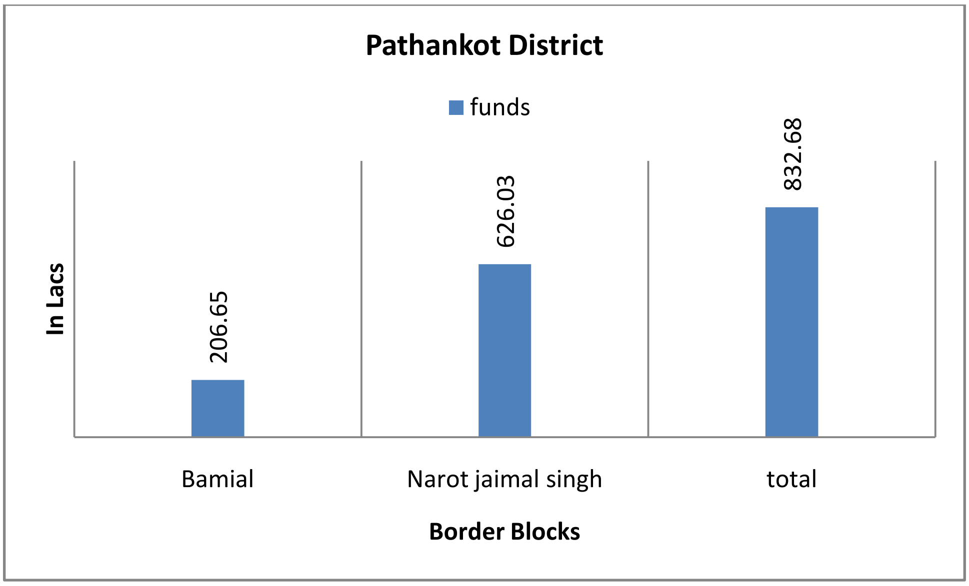
Table 4.44: Allocation of BADP funds of the selected border districts of Punjab from the year 2015-16 to 2019-20*

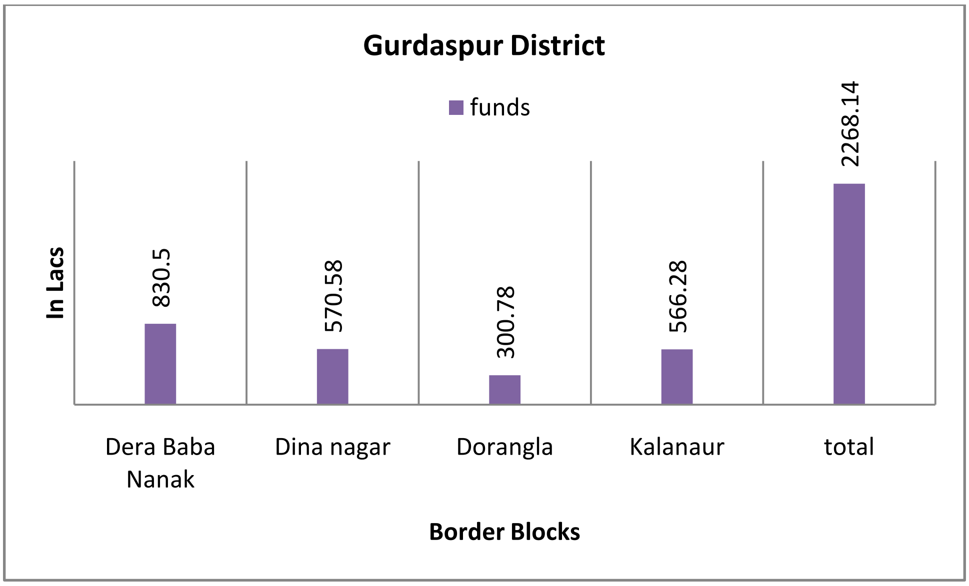
S. No.	District/Block	2015-16	2016-17	2017-18	2018-19	2019-20	TOTAL
1	**PATHANKOT**						
	Bamial	49.75	29.15	48.39	36.02	43.34	206.65
	Narot Jaimal Singh	112.68	97.31	161.87	111.52	142.65	626.03
	TOTAL	**162.43**	**126.46**	**210.26**	**147.54**	**185.99**	**832.68**
2	**GURDASPUR**	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**Total**
	Dera Baba Nanak	160.53	124.71	207.86	154.83	182.57	830.5
	Dina Nagar	113.06	85.47	142.46	106.06	123.53	570.58
	Dorangla	58.86	46.49	77.99	49.14	68.3	300.78
	Kalanaur	110.73	85.91	143.20	100.24	126.2	566.28
	TOTAL	**443.18**	**342.58**	**571.51**	**410.27**	**500.6**	**2268.14**

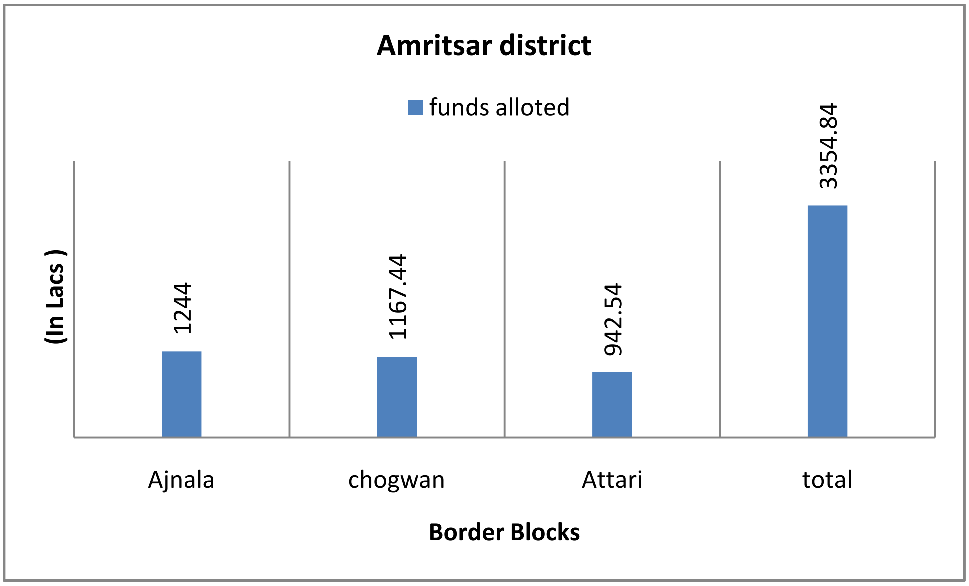
S. No.	District/Block	2015-16	2016-17	2017-18	2018-19	2019-20	TOTAL
3	**AMRITSAR**						
	Ajnala	247.03	188.45	314.11	219.33	275.94	1244.86
	Chogawan	241.33	174.93	291.97	204.11	255.50	1167.44
	Attari	184.47	143.17	238.63	167.04	209.23	942.54
	TOTAL	**672.83**	**506.55**	**844.31**	**590.48**	**740.67**	**3354.84**
4	**TARN TARAN**						
	Bhikhiwind	170.29	131.47	219.13	153.43	207.52	881.84
	Gandiwind	86.31	66.75	111.25	77.88	120.84	463.03
	Valtoha	275.78	215.84	359.78	251.78	317.71	1420.89
	TOTAL	**532.38**	**414.06**	**690.17**	**483.09**	**646.07**	**2765.77**
5	**FEROZEPUR**						
	Ferozepur	277.67	216.60	361.03	252.69	327.66	1435.65
	Guru Har Sahai	200.52	154.97	258.30	180.84	224.39	1019.02
	Mamdot	247.89	193.95	323.28	226.64	288.02	1279.78
	TOTAL	**726.08**	**565.52**	**942.61**	**660.17**	**840.07**	**3734.45**
6	**FAZILKA**						
	Fazilka	350.92	273.01	455.05	318.51	400.68	1798.17
	Jalalabad	228.37	176.59	294.34	206.07	256.02	1161.39
	TOTAL	**579.29**	**449.6**	**749.39**	**524.58**	**656.7**	**2959.56**
Total	**6/17**	**3116.19**	**2404.77**	**4008.25**	**2816.13**	**3570.10**	**15915.44**

*Source: BADP; Dept. of Planning, Govt. of Punjab.

The following Fig. 4.54 represents the block-wise allocation of BADP fund of each district. They represent the total amount received by each block per district over the last five years along with the total amount of funds allotted to the district from the period 2015-16 to 2019-20.


Pathankot District
funds
In Lacs
206.65
626.03
832.68
Bamial
Narot jaimal singh
total
Border Blocks


Gurdaspur District
funds
In Lacs
830.5
570.58
300.78
566.28
2268.14
Dera Baba Nanak
Dina nagar
Dorangla
Kalanaur
total
Border Blocks


Amritsar district
funds alloted
(In Lacs)
1244
1167.44
942.54
3354.84
Ajnala
chogwan
Attari
total
Border Blocks

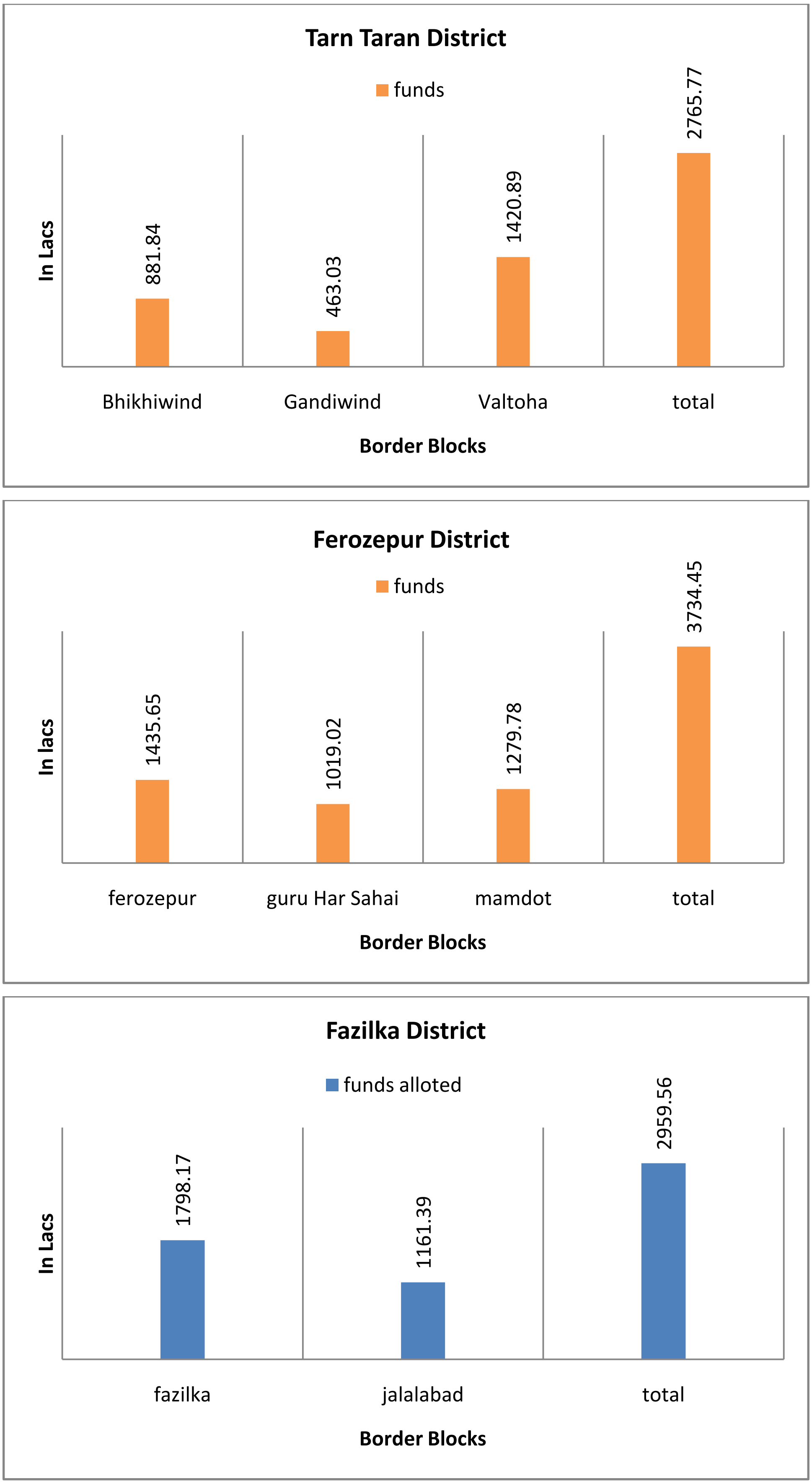


Fig. 4.54: Allocation of BADP funds of the selected border districts of Punjab from the year 2015-16 to 2019-20.

In District Amritsar the border blocks Chogawan (1167.84 lacs) and Ajnala (1244.86 lacs) have been given almost equal amount of funds as compared to Attari that received 942.54 lacs in the span of five years from 2015-16 to 2019-20. The data of District Fazilka shows the allocation of more funds (1798.17 lacs) to Block Fazilka as compared to block Jalalabad (1161.39 lacs) during the same time period.

In district Ferozepur three border blocks have received nearly similar amount of funds. But border block Ferozepur was allotted the highest amount of 1435.65 lacs in five years while block Guru Har Sahai was allotted the least amount of 1019.02 lacs in the same time period.

The maximum funds received by block Dera Baba Nanak in these five years followed by block Dina Nagar and Kalanaur while the block Dorangla was allotted the least amount of funds in the tenure of 5 years from 2015-16 to 2019-20.

In case of district Pathankot there are only 2 border blocks i.e. Bamial and Narot Jaimal Singh. The latter block was allotted the maximum of funds (626.03 lakhs) whereas block Bamial received only 206.65. District Tarn Taran has 3 border blocks i.e. Bhikhiwind, Gandiwind and Valtoha. The maximum funds were allocated to Valtoha (1420.89 lacs) followed by Bhikhiwind (881.84 lacs) and the least amount of funds were allocated to Gandiwind block (463.03 lacs).

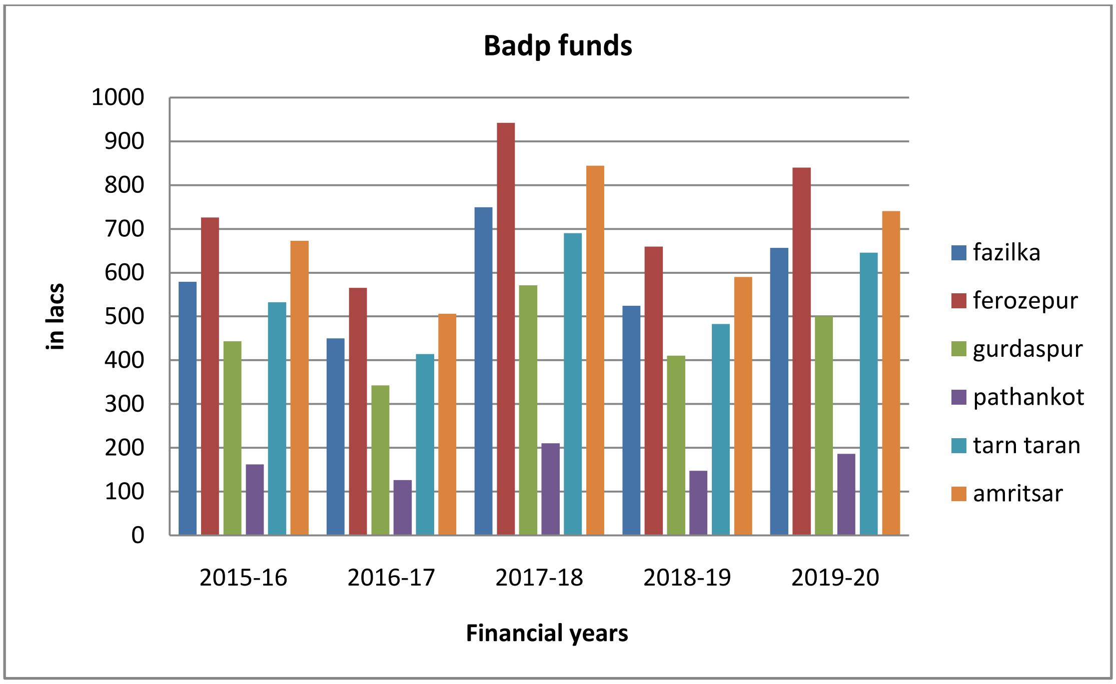


Fig. 4.55: BADP fund allotment in the selected border districts from the year 2015-2020.

From the Table 4.44 and Fig. 4.55, it is very evident that in the period of five years starting from 2015-16 to 2019-20, the six border districts have received varying amount of funds under BADP. Every year these funds are utilised in different development related activities as specified in the guidelines. Depending on the progress of work done under the previous funds and the requirement of the development sector, the funds are distributed up to a maximum amount, as shown in the following Table 4.45:

Table 4.45: Sector-wise allocation of BADP funds as per the guidelines

S. No.	Development Sector	Percentage (%) of funds to be spent*
1	Agriculture	10 max.
2	BGFs	10 max.
3	Education	5 min.
4	Health	10 min.
5	Infrastructure	35 max.
6	Social sector	30 max.
7	Sports	5 min.
8	Special area scheme	10 min.
9	Maintenance	15 max.
10	Reserve	1.5 with max. of 50 lacs

**Source: BADP; Dept. of planning, Govt. of Punjab.*

The distribution of funds on the above basis was done as per the BADP guidelines but later on in 2018-19 the guidelines were modified and the funds allocated were distributed on the following basis as per the Table 4.46:

Table 4.46: Sector-wise allocation of BADP funds as per the new guidelines.

S.No.	Criteria	%age of funds to be utilized
1	Population	nearly 30%
2	Area (sq. kms.)	nearly 31%
3	International border length	nearly 39% (including administrative expenses 1.5%)

CHAPTER 5

DISUCSSION

A village constitutes the fundamental and important developmental block of a country. If a nation has to progress and develop, it is the villages which have to develop first – a bottom-up approach. Sustainability is the key to development and to meet sustainable development goals, an initiative of the Central Government of India Sansad Adarsh Gram Yojana (SAGY) in 2014. The basic purpose of the programme was the upliftment of rural areas through effective implementation of various rural development schemes or initiatives. This concept was followed by smart village concept the world over in 2017. For a village to be smart and sustainable it has to be smart in agriculture, environment, socio-economic status, soil & water smart. This could be achieved with the programmes of rural development. Punjab is a small triangular state in north western part of India which shares its international border with Pakistan. Known for its fertile soil and large-scale production of food grains, the whole agriculture of the state is dependent on groundwater for irrigation and drinking purposes. Agriculture is the primary occupation of the larger fraction of the rural dwellers and a recent trend of overuse of fertilisers, pesticides and excessive cultivation has brought serious environmental and health problems in the state especially in the Malwa region. Contamination and overuse of the groundwater has become a serious issue in Punjab and also the world over. People in the state are suffering from health issues like cancer, kidney ailments, infertility etc. The state has witnessed the lowering of groundwater table, decline in the quality of water due to leaching of fertilizers etc. and air pollution due to industries and certain agricultural practises. Out of the 29 districts in Punjab, six districts share border with Pakistan. Due to long term terrorism and being in the vicinity of international border, many of the villages especially the ones near the zero line in these border districts had been suffering due to insecurity and inaccessibility. Thus, it becomes necessary to evaluate these villages and find out their actual problems and challenges.

The current research is an earnest effort to analyse the environmental, social, economic aspects, quality of soil & water and level of development with reference to some rural development schemes as well as through survey. These villages being very close to the zero line are not very approachable and lack in many facilities while essential commodities do not reach to the people living here. The critical evaluation of some of the villages that were selected randomly from these six border districts of Punjab has been done. The selected villages were analysed for the socioeconomic, developmental and environmental status. Many of the border villages share two rivers i.e. Sutlej and Ravi with the neighbouring nation. It thus, becomes essential to assess the quality of soil and water. For this purpose, the quality of groundwater and municipal water was checked by estimating the physical and chemical attributes such as electrical conductivity, TDS, pH, alkalinity, hardness, fluoride, chloride nitrate, magnesium and sulphate ions. Apart from this soil samples were also collected, put to physico-chemical analysis for parameters like pH, bulk density, electrical conductivity, moisture content, soil organic matter, soil organic carbon, nitrogen, potassium and phosphorus. Apart from these heavy metals like selenium, cadmium, chromium, nickel, lead, mercury, uranium was also analysed.

The quality of soil and water depends upon its physiochemical parameters which fluctuate or show variation due to seasonal as well as anthropogenic factors. It is the requirement of the present times to evaluate the quality parameters of these two natural resources in this particular area of Punjab.

5.1 Monitoring of socio-economic and environmental issues

5.1.1 Socio-economic Issues

Basic amenities play a very pivotal role in the progress of a village/ town/ district or a state as these are the essentialities that make the living comfortable and progressive. It is important to mention here that there is a long way to go for the border villages (85.2%) to have 100% accessibility with all-weather metalled roads. This facility is present in only 6% villages (Fonceca, D.C.M., *et al.,* 2018) and as per a report of Centre for budget and Governance Accountability, India 2013, only 33% of the total rural road network is available. The infrastructural gaps need to be addressed for proper growth and development of rural areas. Similarly, streets are getting better (73.5%) with laying of concrete or interlocking tiles but drains are by and large still uncovered and uncemented which makes the environment unhygienic and unhealthy, leading to water borne diseases and infections. The sanitation facilities available in the villages also need attention of the higher authorities for more fund allocation and their effective utilization towards the same to make these border villages a better place to live. It has also come to light that here sports are a neglected segment and the athletic potential of many youngsters is being unrecognized.

In majority of the villages, 25-35 years age group comprises a lower percentage (9.4%) in comparison to the mature 46-55 years age group (33.3%) which is indicative of the fact the young generation is fast moving or migrating out of the villages and districts in pursuit of better future prospects. This is due to the lack of basic facilities like education, health, sanitation, remoteness and sensitivity of the study area. In a survey- based study on rural migration of youth in district Hisar in Haryana, 95% of the youth said better job opportunities, 91.74% said better educational opportunities and 87.61% said better facilities for earning livelihood were some of the reasons of migration (Tripathi, H. *et al.,* 2018).

Agriculture is the primary sector of employment (46%) and income for the people in rural areas (Singh, K., Rangnekar, U. S., 2010; Sekhon, J. S., 2014; Kapoor, R., 2019). It is therefore the need of the hour that policy makers should engage experts from government agencies/ institutes or NGOs etc. to educate and create awareness in the farmers about the new and sustainable agricultural techniques/practises which would enhance their income. They should be encouraged to use non-conventional energy resources and new irrigation methods for crop cultivation- a step towards sustainable agriculture and these villages environment and water smart.

The study revealed low interest in education among the villagers of the border belt. The survey found that poor infrastructure of schools, less availability of institutions of higher education in & around villages, high dropout rate and educational qualification of parents are some of the major hurdles. Dropout rates are less in families with better house holdings. The findings were similar with the earlier ones (Mahalanabis and Acharya., 2021). Number of illiterates (24.51%) and low percentage in level of education (31.37%) is due to factors like poor school infrastructure, distance of school from home, family background, education level of parents and dropout rate of children especially at secondary level. In the present study there are 82.35% middle schools and only 29.4% high schools against 100% primary schools available in the villages under survey. Punjab has witnessed the massive hike in the dropout rate of 17.2% against the national average dropout rate at secondary level of 12.6% for the year 2021-22 (press release, 2023). A survey study on rural demography of India, 42% females and 22% males had no prior school attendance, while 18% of females and 21% of males had less than 5 years of completed education (Sekher, T.V. 2011). It is therefore suggested that the various rural development schemes that are implemented should focus more on quality of education. Recruitment of permanent teachers against the vacant posts to improve the education sector and better job opportunities (Kaur, S. 2016) in the vicinity of villages can be a measure to enhance employability. There are various central/state sector schemes meant for development in education but the border districts seem to be lagging behind. To understand the purpose of education, paternal education also matters. It is emphasised that improving school infrastructure, quality of education, and investment in job opportunities can prevent dropout rate to a certain extent. The goal of universalizing better school education in India is not possible until there is a substantial enhancement in household economic conditions and a shift in parental social attitudes.

Majority (32.9%) of the population investigated had an income up to Rs 5000 per month which reflects a poor standard of living and thus poor availability of commodities. This could be due to lack of good nearby markets as well as low purchasing power of the villagers. Here 30.78% of the investigated population has small size of landholdings (1-4 acres) and 28.82% are engaged as labour. Another reason could be non-availability of skill development programme and entrepreneurial facilities. To meet the gap between the earnings and the expenditure, villagers often resort to credit money, preferably from banks rather than taking it from relatives or moneylenders. The findings are similar to the ones done in a study on employment diversification in rural India (Kaur, A., *et al.,* 2019) But there is 15.1% of the population that has never taken credit money from any of the above-mentioned sources. In a study in Pakistan, it was observed that factors like farming experience, total landholding, monthly income, education, family size etc. had significant role in farmers assess to credit. Socio economic factors play an important role in assess to agriculture credit (Saqib. S.E., *et al.,* 2018).

About 50% of the population of the surveyed area have no agricultural land of their own as 28.82% of the people is engaged in labour. Majority of the farmers (30.78%) had small (1-4 acres) size of land holding. In a study conducted on rural India it was found that marginal landowners have higher probability to work as Labour in the farm as compared to casual labour in non-farm (Kaur, A., 2019). There seems a positive correlation between rural credits and size of the land holding. The findings are similar to the previous done studies (Chandio, A.A., *et al.*, 2020).

In the present investigation the results of the health issues of the respondents showed that 35.1% of the overall respondents and 21.6% suffered from high blood pressure and diabetes respectively (Patil, A.V., et al.,2002) whereas overall 18.6% population is healthy and did not suffer from any kind of illness or health issue. In addition to the primary occupation many people practice dairy farming as supplementary source of income to have better standards of living. Thus, the state authorities should focus on providing veterinary facilities which are lacking, to the milch cattle of these areas for timely medical assistance to the ailing cattle.

5.1.2 Environment Awareness and consciousness

Because of the non-standardised and unscientific approach, the farmers apply high (excess) dosage of pesticides (87.6%). They also have a misconception that more the quantity of pesticides they apply the better will be the results (Mabe, F.N., *et al.,* 2017) which is posing an increased risk to health and environment. It is important that formal education and training must be provided to the farmers by the personnel of state agriculture department. Moreover, the survey shows that due to low level of education, the farmers use the agro-chemicals not only from their own experience but also rely on the recommendations and suggestions of the sellers/retailers. Being uneducated they do not read the instructions and composition mentioned on the containers of fertilizers and agrochemicals (Hou, B., Wu, L., 2010). Another factor that contributes to the prevalent usage and purchase of these products is their easy availability in the local market. Hence it is recommended that rural development agencies must focus on the quality of education.

65.8% of the respondents practice stubble burning and 84.9% of them dump the waste and dispose the grey water in the open. Only 23.7% of the farmers practise crop rotation and a very small percentage of 6.4% of the farmers are aware of the importance of the soil and water quality.

There has been found a direct correlation between the level of education of the farmers and the environment awareness especially related to pesticide application. 45.8% of the farmers who apply pesticides and 43.2% of them who use fertilisers in their fields are uneducated or illiterate. This is contradictory to the earlier findings

(Akca, H.M., *et al.,* 2007). Out of the 60.6% who use approximate dose of the pesticides or agrochemicals, only 13.9% are aware of the importance and safety usage of recommended dosage to be applied (Hou, B., Wu, L., 2010).

5.2 Soil analysis

The soil samples were analysed and majority of the parameters were within the permissible limits as prescribed by WHO the samples collected from almost all the locations

5.2.1 Physico-chemical parameters

Soil texture is the composition of soil or the relative percentage of particles of different sizes that is sand (0 .75- 1.5 mm), silt (0.75- 0.2 mm) and clay (0.02-0.0015mm) (USDA,1987). The size of the soil particles has a significant contribution to its physico-chemical properties, moisture content (Hassink,1994) and concentration of heavy metals (Rani, J., *et al.*,2021). In this work undertaken, the composition of soil samples taken up from the 34 selected locations showed variation. The content of silt was low and was observed to be 14.1% to 37.8 1% followed by sand 20.89% to 50.22% and content of clay was high ranging from 16.53% to 60.37%. All the soil samples studied were of different categories as per the soil textural triangle (USDA Fig. 5.1 & Table 5.1).

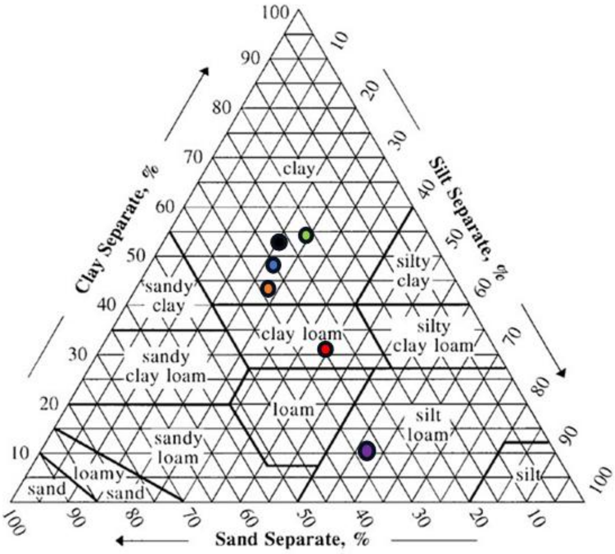


Fig. 5.1: Soil textural triangle for soil samples of border districts of Punjab

Source: USDA (Soil Textural Triangle)

Table 5.1: Soil Composition Index of border districts of Punjab

S.No.	District	Soil composition
1	Pathankot	🔴
2	Gurdaspur	🟢
3	Amritsar	🟣
4	Tarn Taran	⚫
5	Ferozepur	🔵
6	Fazilka	🟠

(Zeki, G., *et al.*, 2010) reported the soil texture and composition of saline and alkaline grassland soils of Kayseri, Turkey. The content of sand, silt and clay vary from 17.2 - 93.4%, 3.15 - 67.0 % and 0.62 - 73.4%, respectively. Sand 46%, silt 20% and clay 41% was the soil composition in the samples taken up from some parts of Columbia (Marín-Pimentel *et al.*, 2023). In the surface soils samples in the Damodar River basin, sand was 39.78 to 79.46%, silt 6 to 40% and clay 13.38 to 22.56% whereas the sub surface soils showed 35.60-81.36% sand, 5 to 48% silt and 11.43 to 20.50% clay (Hoque, M. M, *et al.*, 2023).

pH is a very essential parameter related to alkalinity or acidity of the soil. The acidic nature of the soil indicates its chemical composition which directly influences the nutrient availability to the plants (Adhikary, 2014). Variation in the value of pH is seasonal but several anthropogenic activities also influence it and make the soil toxic. The soil samples collected from various locations selected for the present study were slightly alkaline in nature with pH range of 6.73-9.0. The results were similar to the previous reports (Joshi and Kumar 2011) of agriculture soils of Sanganer region of Jaipur, Rajasthan with pH in the range 7.62-9.2. Moderate to alkaline nature of soils are present in Hisar district with pH in the range of 8.0-8.5 (Louhar *et al.*,2020). The pH in some villages of Punjab was found to be slightly alkaline i.e. 7.92 - 8.38 (Sharma, P. & Kaur, J., 2022) while the average pH of the soil samples analysed in SW Punjab was 7.81- 8.25 (Rani, J., *et al.*, 2021).

Electrical conductivity is the salinity measure of the soil. In the current study the soil samples had electrical conductivity in the range of 65 to 268.67mS/cm which is well within the limits. It was found low (0.220- 0.602mS/cm) in the soils of some villages of Punjab situated near the banks of rivers Sutlej and Beas (Bhatti, *et al.*, 2016a) while its minimum value was 0.307mS/cm and maximum value was 0.723mS/cm (Bhatti, *et, al.,* 2016b). In a survey in some villages of Ludhiana, the electrical conductivity was found in the range of 23.33 to 35 mS/cm (Sharma, P., & Kaur, J. 2022).

Soil moisture or moisture content (MC) is the quantity of water that soil contains and is a vital constituent for plant growth. It is essential for photosynthesis, regulates soil temperature and acts as a nutrient. It helps in the easy absorption and assimilation of nutrients in the plants. It interacts with contaminants in the soil and also has an impact on the soil microorganisms (Stark and Firestone,1995; Pan *et al.,* 2012). The moisture content in the soil samples taken up in the present work ranged from 4.35 to 24.9 % and the mean value was 13.183%. This could be related to the clayey loam nature of the soils. Clay has good water holding capacity and retains moisture for a longer time. The maximum mean moisture content was 17.58% in the soil samples of Pandoga sub water shed in district Una, H.P. (Sharma, B., & Bhattacharya, S., 2017).

Bulk density (BD) is an indicator of the compaction and porosity of soil. High bulk density means that the soil has low porosity and low compaction and the ideal range is 1 to 1.6 gm/cm^3. Bulk density in the soil samples taken up under study showed a mean value of 1.043 gm/cm^3 and had a range of 0.79-1.283g/cm^3. It is well within the range and indicates more clay content in the soil samples. Greater is the amount of pore size hence good porosity and compaction properties. The soils are thus suitable for the healthy root growth and absorption of nutrients from the soil. Bulk density in soil samples from some villages of Punjab near river Beas and Sutlej has been found in the mean range of 0.92 gm/cm^{3}to 1.20 g/cm^3 (Bhatti., *et al.,* 2016a). In a comparative study conducted in Zambia on soil samples of local forest, overburdens and trailing dams, the bulk density mean values were 1.24, 1.44, 1.49 g/cm^3 respectively (Chileshe, N.M., *et al.,* 2020).

Organic carbon is a measurable component of soil organic matter and pertains solely to the carbon component of organic compounds. It is crucial to the physical, chemical and biological functions of agricultural soils. In the present study the mean value was 0.424% and range was 0.25-0.71%. It has a great influence on retention of the heavy metals in the soils (Troeh &Thompson, 2005). The maximum mean value was found to be 0.83 gm/cm^{3}and is ideal for the soils. A study was done on bulk density and its relation with other soil parameters, in the soil samples taken up from the Pandoga watershed area in Una District (Sharma, B. & Bhattacharya, S., 2017). On an average the soil samples of different villages from district Sangrur, Punjab, the range of OC was 0.87-2.49% (Sharma & Chahal., 2018). In a similar study carried out in district Jalandhar of Punjab, the organic carbon in the roadside agriculture soil samples range from 1.78 to 6.19% (Dogra, N. *et al.,* 2019). A study conducted to assess ecological risk of heavy metals and their spatial distribution in the agriculture soils of northeastern Iran, the organic carbon component was found in the range of 0.17-0.73% (Keshavarzi, A., Kumar, V., 2019). It was found to be 0.15- 0.53% in the top soils while the subsoils have organic carbon in the range of 0.19- 0.66%. This was reported in a work done to assess heavy metal pollution and its ecological risks in the mid channel bars in the sub-tropical river basin of the Damodar Valley where agriculture is the primary occupation (Hoque, *et al.,* 2023).

Soil organic matter (SOM) is the humus formed by the decomposition of dead and decaying plant and animal tissues. It mainly consists of minerals and nutrients like carbon, nitrogen, phosphorous, calcium, magnesium etc. (Bot and Benties, 2005). SOM (%) values in the present soil samples were comparatively low (0.43-1.221%) than the minimal value of 3.40% (Plunkett, 2010). There has been a positive correlation between organic carbon and soil organic matter in the samples (r=0.916). It was found in the range of 2.73-4.14% in the agricultural soils of Punjab (Bhatti, S., *et al.,* 2016b).

The nitrogen content in the soil samples under study were in the range of 15.33 to 95.07 g/kg and the mean value of 62.813 g/kg. There has been found a positive correlation between phosphorus and nitrogen content of the soil samples under study (r=0.663). It means that both nitrogen and potassium are directly correlated to each other, if one of them increases the other one automatically does show an increase in its value. (Yao et al., 2013) investigated the impact of sewage irrigation on China's agricultural soils and discovered that the mean content of waste water and regularly water-irrigated fields was 653.18 mg/kg and 514.17 mg/kg, respectively. The nitrogen content in the soils of Tripura was 0.01 to 0.29 g/kg and a mean value of 0.11 g/kg (Reza, S.K., *et al.,* 2019). While studying the physico- chemical attributes and heavy metal concentration in copper mines in Zambia it was found that nitrogen content is in the range of 1.41 to 2.24 mg/l (Chileshe, M.N 2020).

Phosphorous has a very pivotal role in the growth of roots and fruits as well as in providing disease resistance to the plant. Because of slow depletion, it is a restricting nutrient for plant growth and is available in the form of inorganic phosphate. Both forms of phosphates i.e. organic and inorganic phosphates are present in soil (Igual *et al.,* 2001; Rodriguez *et al.,* 2006; Thuynsma *et al.,* 2014). Over application of phosphorus fertilisers to increase the crop yields has led to deterioration of soil, eutrophication of water and damage to the environment (Vance *et al.,* 2003; Conley *et al.,* 2009; Richardson *et al.,* 2009; Shen *et al.,* 2011 Wu *et al.,* 2013). Four samples out of the samples taken from various agricultural fields in Amritsar, Punjab, (Katnoria *et al.,* 2008) reported the concentration of phosphates as 0.75 mg/g to 6.90 mg/g. High phosphorous content (108.44 mg/kg and 23.43 mg/kg) was reported in the soils irrigated with sewage and canal water respectively (Rai *et al.,*2011). While studying heavy metal bio accumulation in fodder crop cultivated in certain areas of Punjab, (Bhatti, S., *et al.,* 2016b) phosphorus was in the range of 49.99-384.91mg/kg. In this current investigation the phosphorus content was quite low in the range of 4.233 – 25.877 g/kg and a mean value of 13.659 g per kg.

Potassium is the most abundant element which is required for absorption and retention of water, helps in turgor generation & activation of enzymes in plant cells (Britto and Kronzucker, 2008). The analytical parameters of the soil influence the availability of potassium, which varies depending on the type of soil. The potassium content of the soil samples from the chosen sites was determined in the current study and was found to be between 36.57 and 266.7 mg/kg. (Ma, J., et al., 2014) also revealed that soil samples from four distinct locations in an oil-producing region of China had available potassium contents of 235.97, 137.24, 162.80, and 112.40 mg/kg. It was reported in the range of 73.08 to 261 mg/kg in another study in Iran (Keshavarzi and Kumar., 2019).

5.2.2 Heavy metals analysis

As one of the most significant sinks of heavy metals, soil is subjected to an array of human and natural activities, such as the excessive use of agro-chemicals, pesticides, fertilisers, rapid industrialisation, effluent discharge that continuously contribute to heavy metal accumulation. This significantly inhibits the microbial activity in the soil (Aceves *et al.,* 1999). These heavy metals pose health risks through dust inhalation, dermal contact and contaminated food, water as well as ingestion through soil-crop system. (Aelion *et al.*,2009). More than 19.4% of the arable land soil is contaminated with Ni, Cu, Hg, Cd, DDT and PAHs (Zhang *et al.*,2011). In the present work we have estimated the content of selenium (Se), cadmium (Cd), arsenic (As), lead (Pb), mercury (Hg), nickel (Ni), chromium (Cr) and magnesium (Mg) in the agriculture soil samples of the study area.

Arsenic enters into soil through natural resources such weathering of rocks, geothermal processes, sulphide oxidation and alkali desorption (Smith *et al.,* 1998; IARC, 2004; Ravenscroft *et al.,* 2009) whereas anthropogenic sources include extreme application of pesticides, mining and industrial activities, disposal of untreated industrial wastes in soil and water bodies and use of the hence polluted groundwater for irrigation (Gulz *et al.,* 2005; Lee *et al.,* 2008; Lim and McBride, 2015). Arsenic content in the soil sample under study was in the range of 0.006-0.08 mg/kg and was within the maximum acceptable limit of 20 mg/kg as given by the European community of Agricultural Soils. This gradually gets contaminated and accumulated in the food crops and enter the food chain leading to number of health issues in human beings. In another work 0.21 - 2.61 mg/kg content of arsenic was analysed in pre monsoon season while 0- 36.67 mg/kg was found in the soil samples in post monsoon season in Peenya industrial area, Bengaluru (Gupta M, N *et al.,* 2019).

Chromium is a carcinogenic toxic element and is harmful even at minute concentration. Long term exposure is harmful and there is no direct causeway and effect between various plant processes and enzymes leading to deterioration of growth and development of the plants. Soil composition also affects the absorption of chromium. More sand component leads to lesser accumulation as compared to high clay or sand content (Jung, 2008). The chromium content in the soil samples in the present work was in the range of 0.006-0.086 mg/kg and is well within the permissible limit. It was not detected in 20.6% of the soil samples. The highest mean values are in the soils of district Tarn Taran and Gurdaspur 0.043 mg/kg. It was 3.71-15 mg/kg and 28.3- 203.6 mg/kg during the pre and post monsoon seasons respectively in a study of spatial distribution of heavy metals in the soil samples of Peenaya industrial area (Gupta M, N., *et al.,* 2019). The concentration of Cr in soil samples ranged from 1.61–3.35 (mg/kg) in a village-based study in Punjab (Sharma, P. & Kaur, J., 2022).

Lead is the highly toxic heavy metal that enters the human body through respiratory and digestive system thus disrupting the various body functions and also the growth of plants by destruction of the chlorophyll pigment (Jaishankar *et al.,* 2014., Su, C. *et al.,* 2014). In the present work, lead content in the soil samples taken up from various locations was well within the permissible limit and the range is 0.010-0.02 mg/kg while no detection of lead was there in 58.8% of the soil samples. Although it is within limits but content of lead is highest (0.015mg/kg) in district Amritsar. The lead content was in the range of 0.1920-0.42 mg/ kg in the samples collected from undisturbed sites while characterization of soil in Peshawar, Pakistan (Wahid, *et al.,* 2019) The average value of lead during a study done in certain parts of District Jalandhar, Punjab showed an average value of 0.041µg/g (Dogra *et al.,* 2019). The mean value of lead was in the range of 3.5–31.5 (mg/kg) in a study conducted in the villages of Ludhiana District Punjab (Sharma & Kaur.,2022).

Cadmium is another toxic heavy metal that induces oxidative stress in plants by disrupting the functioning of cellular enzymes (Irfan *et al.,* 2013). It was found between 1.12 to 6.27 mg per kg in pre monsoon season and 0 to 4.8 mg per kg during the post-monsoon season in the soil samples that were taken from Peenaya Industrial area, Bangalore (Gupta, M, N., *et al.,* 2019). In the present selected area, content of cadmium was within the limits (0.003-0.02 mg/kg). It was not detected in 23.5% of the samples and well in the limit of 0.02mg/kg. The concentration was highest (0.019 mg/kg) in district Tarn Taran. This could be due to human activities and practises like discarding of waste water, excessive use of fertilisers and pesticides and use of polluted water for irrigation. In normal soils the range of cadmium varies as 0-1 mg per kg, 3 mg per kg in slightly contaminated soils, up to 10 mg per kg in highly polluted soils (Irfan *et al.,* 2014; Spence *et al.,* 2014) The mean value of Cd in a study conducted on assessment of soils of agricultural fields in villages of Punjab was 1.61-3.35mg/kg (Sharma & Kaur., 2022).

Although nickel is an essential trace metal and is evenly distributed throughout the soil profile. Human activities such as farming, urban and industrial waste led to its accumulation. The amount of nickel in the soil is influenced by the use of phosphate fertilisers, insecticides, and other factors like electroplating and metallurgy units (Nagajyoti *et al.,* 2010, Wuana and Okieimen, 2011; Hamner *et al.,* 2013). Its impact on human health includes dermatitis, immuno-toxicology, cancer of respiratory tract and nickel poisoning. During analysis of heavy metal content in agricultural soils of some areas in Punjab, the content of nickel was found to be 28 mg per kg (Sharma & Chahal., 2018). The mean concentration of nickel in a study conducted on agricultural soil samples of NCR, Delhi was 34mg/kg (Rani, J., *et al.,*2021). Presently, the nickel content in the samples was in the range of 0.003 to 0.086 mg/l and well within the permissible limits. The highest mean concentration (0.067 mg/kg) was in district Amritsar.

Selenium is a metalloid that is important in the biological processes of animals and human beings. The total amount of selenium in the soils around the world varies according to soil type and ranges from 0.05-0.2 mg/ kg. A study conducted in the northern states of India, selenium content in few areas of Himachal and Punjab was low. In Amritsar district it was 288.9 mg per kg, Khannuri 278.0 mg per kg while contents were low in district Mansa having a mean value of 224.7 mg per kg (Yadav, S.K., *et al.,* 2005). Total selenium content in the soil is determined by the soil formation process and the type of parent rock materials (Imran, *et al.,* 2016). Serious environmental and health concerns are associated with both high and low selenium levels in soil. The fore most important soil variables that impact Se availability are pH, organic matter, soil texture and the presence of competing ions. The crop type also affects selenium intake and accumulation, regardless of whether the crop is an accumulator or not (Imran, M., *et al.,* 2023). The use of fertilisers, burning of fossil fuels, smelting of metals, disposal of solid waste etc. are some of the human activities that contribute to the selenium content in the soils (Joy EJM., *et al.,* 2015). The Se content in the present study was in the range of 0.01-0.056 mg/kg and well within the permissible limits (0.2mg/kg). The mean concentration was highest (0.048 mg/kg) in district Tarn Taran. Six agricultural locations were chosen for soil and water samples for elemental analysis in which selenium was found to be in 2.3 to 11.6 mg per kg at Jainpur and 3.1 mg per kg at Barwa in a case study in the states of Punjab and Haryana, India (Bajaj, M., *et al.,* 2011). The presence of organic matter significantly influences the immobilization of selenium and its accessibility to plants.

An examination of heavy elements and uranium content in soil was conducted at six different locations near the mine area in China. The results indicated that arsenic levels ranged from 605 to 1234 mg/kg, followed by manganese at 247 to 713 mg/kg, and uranium at 20.2 to 43.5 mg/kg (Zhang, Z., *et al.,* 2023). In the current study, the uranium content in the soil samples exhibited a range of 0.003 – 0.086 mg per kg and the background value of uranium is 1-10 mg/kg.

Mercury concentrations in soil exhibit a wide range, spanning from levels below 1 mg/kg, which are considered as background values, to nearly 10,000 mg/kg in contaminated regions (Ottesen *et al.,* 2013; Wang *et al.,* 2012). The mean mercury content recorded in the study was 0.108 mg/kg, surpassing the background concentration of 0.065 mg/kg. This finding suggests that human activities have introduced mercury into agricultural soil in specific areas (Wang, S., Zhong, T., Chen, D., & Zhang, X., 2016). In the present study, mercury content was estimated, and it was not detected in 61.7% of the samples and was in the range of 0.0003-0.003 mg/kg. The maximum mean concentration is (0.002 mg/kg) in district Tarn Taran but well within the permissible limits.

Research studies indicate that prevalent use of chemical fertilizers affect the form of heavy metals. The anions and cations so introduced can precipitate or make heavy metals complex and thus affecting their behaviour in soil and plants (Zhang, Z. *et al.*, 2020). Application of urea fertilizers reduce the pH and increase the content of exchangeable Cd and Pb in the soil and different plant parts (Chen *et al.*, 2010). Similarly, application of ammonium nitrate decreases pH near rhizosphere thus increasing the activity of heavy metals (Lou *et al.*, 2005). Application of phosphorous and potassium decreased the content of exchangeable Cd while potassium chloride promotes its absorption ((Chen *et al.*, 2010; Yang and Yi, 2003). The clay content in soil has a positive correlation with heavy metal content (Chen, F. *et al.*, 2019). At the same time the type of soil in an area depends on topography, mineral content & rock fragment in soil, rainfall and water movement in that area as well as the activities of local plants, animals and human beings (Zhang, Z *et al.*, 2020; Ding *et al.*,2019). Estimation of heavy metals in the soil samples of the study area indicates that though they have been detected but the concentration of the above-mentioned heavy metals is well within the limits.

5.3 Water analysis

Water is the elixir of life and is part of every cell of the living organisms. Life on earth revolves around water. It is available in the form of groundwater which is used for agricultural and drinking purposes (Usha *et al.,* 2011). There has been over exploitation of the water sources which has altered its quality. A number of contaminants both from natural activities like erosion of rocks and sediments by wind & water, leaching of soils (Patil *et al.,* 2012), and anthropogenic activities like agricultural runoff, untreated industrial wastes, metalloids and heavy metals, agrochemical etc. have polluted the ground water and deteriorated its quality (Jain *et al.,*2008; Mahapatra, 2011). Thus, altering its physical, chemical and biological properties making it unfit for the various purposes. It thus, become necessary to check and monitor the quality of ground water (Ramakrishnaiah *et al.,* 2009) by analysing its various physical and chemical properties.

The rivers flowing across the state have great contribution to the soil fertility making Punjab one of the leading producers of food grains & agricultural state of India. The state not only shares its international border but also the rivers or the water bodies with Pakistan especially in the districts near to the border. The groundwater that serves the purpose of drinking as well as irrigation in rural parts of the state (Hundal *et al.,* 2007) has been overexploited and has led to lowering of the water table. And prevalent use of pesticides and chemicals, fertilisers to enhance crop production has deteriorated the water quality leading to many serious environmental and health issues across the state.

In the present work undertaken, an effort has been put to analyse different physical and chemical parameters like pH, TDS, EC, Alkalinity, hardness, chlorides, Fluorides, sulphates, nitrates to determine the quality and suitability of groundwater and municipal drinking water taken up from different sites in the vicinity of international border.

5.3.1 Physico-chemical parameters

To evaluate the quality assessment of water with physical and chemical parameters is an important criterion to determine its level of pollution (Sarkar *et al.,* 2007; Sinha *et al.,* 2009). The estimation of these parameters helps to determine the impact of various natural and anthropogenic factors that influence its quality. All the samples taken up from different locations were classified on the basis of their TDS levels and drinking suitability.

pH is a key variable for determining the water quality. A variation in pH leads to variation in the other physical chemical parameters. The organic and inorganic solutes in the water and reaction of carbon dioxide influence pH (Parihar *et al.,* 2012). The results of the current work shows that the pH ranges between 6.5 to 8.433 and is well within the permissible limits as per Bureau of Indian standards (BIS, 2012) guidelines. Almost all the samples in the investigated area were alkaline in nature. The pH was 8.433 at site FMMH.

EC shows the presence of the different ions in water that assist in conduction of electric current and also influence the taste. It is a good measure of TDS and salinity of water (Rahmanian *et al.,* 2015). All the samples for groundwater and municipal water had it in a range of 105.6-859.6 µS/cm and 104.6-832.6µS/cm respectively. It was found that all samples of municipal water and ground water had EC value well within the permissible limit. Excessive salinity disrupts the nutrient and water absorbing ability of plants by diminishing their osmotic activity (Saleh *et al.*, 1999).

High conductivity causes corrosion of electrical appliances like boilers and water heating systems because of scaling of the pipes (Rahman, M.A., et al 2015; WHO 1996). TDS refers to the total concentration and is the measure of the inorganic and organic solids dissolved in the water. The mean value for groundwater samples was 368.0 mg/l and mean value for municipal water was 291.0 mg/l. Approximately 14.7% of the groundwater samples had value above the permissible limit of 500 mg/l 8.8% samples from municipal water had TDS above the permissible limit. The possible reason could be the leaching (Sharma *et al.*, 2012) of inorganic chemicals through agriculture runoff that cause an increase in the salinity of groundwater. On the basis of salinity, none of the water samples taken up under study fall in the excellent class for irrigation purpose as per the classification given (Wilcox, 1995).

Total alkalinity is the buffering capacity of the water which is due to the presence of bicarbonate ions. In the groundwater samples of Malwa region of Punjab, the alkalinity was found in the range of 318 to 642 mg/l and at a few locations it was above the maximum permissible limits (Sharma, R., 2014). In a study in village Sukena in Maharashtra, the alkalinity of tap water was found for 425 mg/l and for groundwater was 390 mg/l in pre-monsoon samples while it was 525 and 500 mg/l in tap and ground water samples respectively collected in post-monsoon samples (Savale, R. R., *et al.*, 2015). While analysing the physico-chemical properties of river water in Nagaland, the alkalinity was found in the range of 51 to 69 mg/l (Temjen, W., Singh, M.R., 2018). The groundwater samples in the present work had total alkalinity in the range of 153.3-555.3 mg/l and 97% of the samples had alkalinity higher the permissible limit (500 mg/l) while 85.3% (152.0-455.3mg/l) of municipal water samples were above the limit. The overuse of fertilisers in fields, use of soaps and detergents in the household chores or domestic liquid waste, add bicarbonates and carbonates as well as salts of sulphate and nitrates which leach into the groundwater via the soil and thus increase the alkalinity.

Total hardness of the samples of groundwater and municipal water ranged from 103.0 - 381.0 mg/l and in municipal water samples it was from 105.3 mg/l to 368.6 mg/l. 47% of the municipal water samples had total hardness above the permissible limit (200 mg/l) while 64.7% of the ground water samples had value above the permissible limit. To check the quality of groundwater in Malwa region of Punjab, 30% of the samples had the value beyond the maximum permissible limit of 600 mg/l as per BIS standards (Sharma, R.,2018). Water quality parameters of groundwater samples from Khushab city in Pakistan revealed the value of hardness of water was in the range of 110 to 1300 mg/l, much beyond the permissible limit (Arshad, S. *et al.*, 2019). In a study on water quality monitoring of Buddha nullah in Punjab, the total hardness of water samples was found well within the permissible limits of 200 to 600 mg/l, BIS, 2012 (Kaur, J. *et al.*, 2021). The correlation results in the present study suggest that the possible reason could be the leaching of chemical fertilisers and detergents which enter into the soil layers and reach the groundwater table resulting in a change in pH and hardness levels of water. As per the classification based on total hardness, all the samples collected for this study fall in the category of hard water, rendering them unsuitable for drinking purposes.

Chloride anion in all the samples of groundwater and municipal water were in the range of 0.50-38.96 mg/l and 2.63 to 39.21 mg/l respectively. None of the samples had levels higher than the permissible limit of 250 mg/l as per BIS, 2012. However high concentration of chlorides in water can cause a laxative effect, corrosion to metallic pipes, and unsuitability of the water for irrigation of crops (Raviprakash and Krishna., 1989). In a pre-monsoon and post- monsoon study carried out in a village in Maharashtra, the chloride content was found to be above the permissible limits in the post monsoon samples (420 and 300 mg/l) as compared to the pre-monsoon (210 and 150 mg/l) for tap and ground water respectively (Savale, R.R., 2015). The chloride content in groundwater samples taken from eight districts of Malwa region of Punjab was above the permissible limit in 60% of the samples collected (Sharma, R. 2018).

The content of fluoride in the water samples of the present study varied from 0.01-1.567 mg/l in groundwater and 0.01-1.16 mg/l in municipal water. 14.7% of the samples taken up from the ground water and 8.8% of water municipal water samples had fluoride content was above the permissible limit of 1 mg/l prescribed by BIS 2012. Drinking water with fluoride levels exceeding 3 mg/l can lead to skeletal fluorosis, and concentrations exceeding 10 mg/l are associated with digestive issues, skin problems, and physical impairment (Park and Park, 1980; Kataria, 2002). Fluoride concentrations below 0.5 mg/L pose a risk of tooth decay, whereas elevated concentrations result in dental fluorosis (Thivya *et al.,* 2017).

Nitrate serves as an effective plant nutrient with moderate toxicity. The presence of nitrates in groundwater may result from leaching caused by the use of fertilizers during irrigation of crops (Chakraborti, D., et al., 2011). In water samples taken from Muktsar District of Punjab, the nitrate content estimated in the pre and post monsoon season was found to be 62 and 65 mg/l (Kumar, M. *et al.,* 2007). In the present work samples, nitrate in ground water was in the range of 0.167 to 36.03 mg per litre. In municipal water, the range for nitrates was 0.26-21.66 mg per litre. All values were well within the permissible limit of 45 mg per litre as given by BIS, 2012 standards. When its concentration exceeds 45 mg/l, it can potentially pose risks to human health and can lead to a condition known as methemoglobinemia, commonly affecting infants (Jain *et al.,* 2010). While analysing the various parameters in groundwater samples of Punjab, nitrate content was found to be high in 91% of the samples tested and beyond the permissible limit (Sharma, R. 2018).

Sulphate ion content in the municipal water and groundwater samples taken up from the study area ranged from 6.13-218.54 mg/l and 13.89-232.87mg/l respectively. Results showed the in 14.7% of the municipal water samples the sulphate content was above the permissible limit whereas in groundwater 17.6% of the samples had its value above the permissible limit of 200 mg/l. Elevated sulphate levels can result from various factors, like the decomposition of organic matter in weathered soils, human activities, fertilizer application, and leaching (Craig and Anderson; Miller, 1979). It was found above the permissible limit in the 40% samples taken from eight different districts of Punjab (Sharma, R. 2018).

Magnesium content in the drinking water and groundwater samples was also not well within the permissible limit as given by Bureau of Indian standards i.e. 30 mg/l. Results showed that of the 23.5% of the samples exceeded in the amount of magnesium content in municipal water and 29.4 % exceeded the limit in groundwater samples. The possible reason for high content of magnesium in water could be the leaching of nutrients as agricultural runoff, increased discharge of effluents from domestic activities (Sharma *et al.,* 2012). Alleviated levels of magnesium along with that of sulphate in the water can act as a laxative and affect human beings (Subramani, 2005; Grag *et al.,* 2008).

Analytical results of the physico-chemical parameters showed that majority of them were well within the permissible limits of Indian standards. All samples of water were classified as hard with high TH and TA, SO_4^-, Mg ions making them unsuitable for drinking purpose. The fluoride content is also high in 14% ground water and 21% municipal water. At the sometime nitrate content, TDS and EC was also on the higher side at few of the locations. A wide variation in certain parameters shows influence of climatic factors and anthropogenic activities like overuse of fertilizers, agro-chemicals and to some extent anthropogenic sources.

5.3.2 Correlation analysis for physico-chemical parameters

In this work undertaken for study the Pearson correlation coefficient was used to ascertain the relationship between different water quality variables through a correlation matrix. A correlation is said to be direct when a change in the value of one variable is associated with a corresponding change in the value of another variable. A positive correlation occurs when a rise in one variable results in an increase in the value of another, while a negative correlation occurs when an increase in one variable causes a reduction in the value of another. (Thakur *et al.,* 2016). The correlation values which are more than $p \leq 0.05$ for different parameters were considered significant (Antonopoulos and Papamichail, 1991). There has been found a positive correlation in the municipal water samples especially a strong correlation with pH-EC (r=0.343), EC-SO^-_4 (r=0.377), TDS-Mg (0.359) and F-SO^-_4(r=0.399). Similarly, a negative correlation has been found between many of the parameters significant at $P < 0.05$ value.

A strong positive correlation between Mg-NO_3 (r=0.684), Ph-EC (r=0.473), TA-F^- (r=0.421) and TH-TA (r=0.342) in the ground water samples. There are several negative correlations also between the various physico-chemical parameters in the ground water samples of the area under study.

5.3.3 Heavy metal analysis

Arsenic content in the municipal water taken from the study area was found in the range of 0.0001-0.023mg/l whereas the groundwater samples taken up from the same locations were in the range of 0.001 -0.03 mg/l. It was well within the permissible limit of 0.01 mg/l as given by WHO 2006 b. It was not detected in 36% of the water samples collected during study. According to Chakraborti et al (2010), arsenic levels in drinking water samples from Bangladesh were found to be higher than WHO guidelines. The concentration of arsenic in Bhojpur District of Bihar, India (Chakraborti et al, 2016) was 1.805 mg/l which was higher than the concentration found in the present study samples of drinking water but lower than the concentration recorded in groundwater samples. The mean value of Arsenic was 9.37 and 11.01µg/l in Malwa region of Punjab (Kaur, T., *et al.*, 2017). In a report on heavy metal contamination of groundwater in different locations of district Amritsar, it was found in the range of 0.07- 0.168 mg/l and well above the permissible limit (Virk, H.S., 2019). It was reported in the groundwater samples of nine different districts of Punjab in the range of 0.010 to 0.111 mg/l, with highest concentration in district Amritsar followed by Gurdaspur and Tarn Taran (Virk, H.S.,2020).

The values of selenium content in municipal water as well as groundwater were in the range of 0.0001-0.005 mg/l and 0.0001-0.026 mg/l respectively. The mean values for municipal water were 0.0024mg/l and for groundwater it was 0.0064mg/l and within the limit of 0.01 mg/l. It was found that 38.2% of the municipal water and 29.4% groundwater samples had no selenium content detected. While estimating the heavy metals in groundwater of Patiala District of Punjab, the levels of selenium were found to be below the permissible limits of WHO (Sekhon, G, S; Singh, B., 2013). The selenium content in groundwater samples of district Amritsar, Gurdaspur and Tarn Taran were found to be more than 0.01mg/l and it was in the range of 0.010 - 0.094 mg/l (Virk, H.S. 2020).

Cadmium is another heavy metal estimated in the water samples. In groundwater cadmium was in the range of 0.0001 to 0.001 mg/l whereas the municipal water samples showed cadmium in the range of 0.0001 to 0.003mg/l. All the samples of ground as well as municipal water had cadmium content within the permissible limits and was not detected in 77.9% of the water samples. In a study carried out on ground water samples in Bangladesh, the cadmium content in eight samples exceeded the BIS permissible limit of 0.003 mg/l (Chakraborti, D., 2010). Estimation of cadmium in 100 groundwater samples of district Patiala in Punjab was below the permissible limit in all the samples except one where it was 0.006 mg/l (Sekhon, G, S; Singh, B., 2013). The MDLI-metal pollution load index of cadmium amongst eight other heavy metals was found to be high in the groundwater resources in Ludhiana and Patiala Districts of Punjab (Kaur, T. *et al.*, 2014). The status of cadmium content in drinking water samples taken from different parts of Malwa Region of Punjab was found to be high in the range of 0.001 to 2.9 mg/l and 63% of the samples were unsafe due to high cadmium content (Sharma, R; Dutta, A. 2017). In the present work a negative correlation between the cadmium and other parameters of water was found.

Iron content in the municipal water samples varied from 0.001 to 0.028 mg/l with the mean value of 0.013 mg/l whereas in the groundwater samples it varied from 0.01 to 0.056 mg/l. It was well within the acceptable limit of 0.30-1.0 mg/l. It was detected in 98 samples from a total of 240 samples taken from different districts of Malwa region of Punjab. The mean value was in the range of 0.05- 7.6 mg/l with an average value of 0.54 mg/l which is above the permissible limit of BIS (Sharma, R; Dutta, A. 2017). In the groundwater samples of district Amritsar more than 2 mg/l of iron contamination was detected in the range of 2.03 to 14.585 mg/l (Virk, H.S. 2019). Deficiency of iron in human body leads to anaemia and fatigue whereas excess of the same has toxic effects leading to hemochromatosis, a severe disease which damages the body organs.

The lead content in the municipal water samples was 0.0003 to 0.01 mg/l whereas in groundwater samples 0.001 to 0.03 mg/l range and well within the permissible limit of BIS, 2012 and WHO, 2006 (0.01mg/l). It was not detected in 14.7% of the municipal water samples and 8.8% of the ground water samples collected. In a study 91% of the samples of drinking water collected from Malwa region in Punjab were found unsafe because of high content of lead. It was in the range of 0.001 to 28 .04 mg/l with an average of 7.79 mg/l much above the permissible limits. While monitoring the water quality of Buddha Nala in district Ludhiana, Punjab the content of lead was found in the range of 0.07 to 0.53 mg/l (Kaur, J. *et al.,* 2020) and was observed to be above the acceptable limit.

Chromium content was in the range of 0.0001 to 0.002 mg/l in the municipal water samples with mean value of 0.0015mg/l and it was 0.0001 to 0.001 mg/l in the groundwater samples with the mean value of 0.0001 mg/l. Chromium is essential for stabilisation of nucleic acids lipid metabolism and stimulation of enzymes (Chowdhary, S., et al., 2003). All values were well within the permissible limits. It was not detected in 64.7% of the water samples. The groundwater samples in a study conducted in Bangladesh revealed that 18 samples had chromium content exceeding the BIS limit of 0.05 mg/l (Chakraborti, D., et al 2010). The chromium content while monitoring the water quality of a tributary of Sutlej flowing through Ludhiana, Punjab was well within the permissible limit of 0.05 mg/l except at few sites where it was 0.24mg/l, 0.25 mg/l and 0 .05mg/l (Kaur, J. *et al.*, 2020). While assessing the heavy metal pollution in groundwater of Malwa Region of Punjab, India, the chromium content was found in the range of 0.001 to 3.6 mg/l with an average of 0.99 mg/l which is above the permissible limit (Sharma, R., Dutta, A., 2017).

Nickel content in the ground water samples taken from the present area of work ranged from 0.001 to 0.02 mg/l with the mean value of 0.010 mg/l whereas in municipal water samples it was in the range from 0.001 to 0.013 mg/l, mean value of 0.001 mg/l and within the permissible value of 0.02 mg/l as given by BIS 2012. 44% of the samples of municipal water and 29.4% of the ground water did not show any nickel content. In a study conducted on drinking water samples taken from Southwestern Punjab revealed the nickel content in the range <0.2- 308 µg/l and a mean value of 34.6 µg/l. Here 17% of the samples in the study had nickel content above the WHO limits (Bajwa, B.S. *et al.*, 2015). The content of nickel in the water samples collected from Budha nullah in Ludhiana, Punjab varied from 0.1 to 0.27 mg/l and was above the permissible limit (Kaur, J. *et al.*, 2020). In a case study from India, during the assessment of pond water samples, nickel concentration was in the range of 0 .1 – 850 µg/l (Rajput, S. *et al.*, 2020).

The content of uranium in the municipal water samples ranged from 0.003-0.02 mg/l with mean value of 0.0107 mg/l while it was 0.004 to 0.03 mg/l in the groundwater samples and mean value of 0.015 mg/l and within the permissible limit given by BIS (0.03-0.06 mg/l). Drinking water samples from southwestern Punjab were analysed for heavy metal distribution and the results revealed that uranium concentration varied between 0.5 to 579 µg/l with an average of 73.5µg/l. Out of the 498 samples analysed 338 samples had uranium concentration above the recommended safe limit of 30µg/l, WHO, 2011 while 216 sample exceeded the threshold value of 60µg/l recommended by AERB, DAE, India, 2004 (Bajwa, B.S. et a., 2015). The preliminary report on heavy metal contamination of groundwater of Punjab reports that highest content of uranium is in Hoshiarpur district in the range of 2109 to 2277 ppb which is much higher than the average (115ppb) value of uranium content for whole of the state.

Nearly 35% habitations in Punjab have excess concentration of uranium in groundwater as per the WHO limits in districts of Malwa i.e Mansa, Bhatinda, Patiala, Barnala, Sangrur, Moga and Fazilka are most affected (Virk, H.S.2017; Bala, R., Karanveer & *et al*., 2022). Groundwater samples from Patiala district of Punjab showed uranium content in the range of 38 - 267 ppb with the mean value of 68.70 ppb. Out of the 50 habitations covered during the above study 26 samples had uranium content higher than 60ppb (Virk, H.S. 2019).

The data of ground and municipal water of the study area does not show wide variation as evident from the values of standard deviation. The concentration of heavy metals and their desirable levels in drinking water recommended by WHO and BIS show that concentration of all heavy metals is well within the limits. It seems that possible source of heavy metal contamination is geogenic and anthropogenic factors causing leaching into the ground water. It has been seen in the present study that as we move from north-eastern part of Punjab (Pathankot) towards south-west (Fazilka), the content of heavy metals increases due to geogenic factors, sedimentation of river soil and parent rock material. Amritsar and Tarn Taran lie near the middle of the Indo-Pak border length, the slope of state descends from north to south, so much of the heavy metals have been found here due to more content of sand, low SOM, low BD and alkaline pH. Soils with such properties have greater retention and decreased solubility of heavy metals (Bhatti, S., *et al*., 2016). It has been found that the content of heavy metals in municipal water is lower to those found in ground water samples reflecting the need of a more effective water treatment to keep the supply safe. The detection of heavy metals in the soil and water samples taken up from study area is a matter of concern which needs timely intervention in order to prevent their potential risk to human health and environment.

5.4 Phytoremediation

Various heavy metals like Se, Ni, Mg, Cr, Cd, Pb and As have been detected in the soil samples collected especially heavy metals like Selenium, Uranium, Arsenic and Nickel which are more harmful and toxic, from the soil samples of study area. Being non-biodegradable, their accumulation not only affect human but environment health also by contaminating soil and water resources. These non-biodegradable contaminants would enter the biological system, show bioaccumulation and move from one trophic level to another (biomagnification) thus entering the food chain.

It has been observed during the survey of the study area that trees like *Dalbergia sisso, Eucalyptus sp., Melia azedarach, Leucaena leucocephala, Albizzia lebbek, Morus alba, Populus nigra, Ficus religiosa, F. bengalhensis,* shrubs like *Ricinus, Prosopis, Cannabis sativa, Vetivera zizandoides,* herbs such as *Phaseolus vulgaris, Ageratum, Datura, Calotropis, Argemone, Achyranthes aspera* and aquatic flora like *Cymopogon, Eichhornia crassipes, Typha, Hydrocotyle spp* etc. are part of the vegetation of the border belt. Most of these plants of the study area are known hyperaccumulators of heavy metals like As, Pb, Hg, Cd, Ni etc (NAAS, policy document, 2022) thereby indicating a huge potential of phytoremediation (Rai, P.K.,2018). It may be thus suggested that where ever possible mass level plantation of such quenchers of heavy metals should be encouraged. Community engagement and good communication with them would play crucial role in the success of phytoremediation (Priya, A.K., *et al.*, 2023).

It is therefore essential to involve local people in the process of soil and water phyto remediation programmes. The village residents should be sensitized for ill effects of heavy metals and the role of the above stated herbs and trees in saving the sound quality of environment. Farmers should be encouraged to conserve such indigenous plants which grow in the wild and also plant them in the community land area (Panchayati land). Saplings of the trees and shrubs which have the potential as hyperaccumulators should be distributed free of cost, by the Forest department. Plantation of some of the above-mentioned plants like *Morus, Melia, Albizzia* etc. could be promoted under plantation drive programmes of social forestry segment of Forest department. This mitigation would improve the quality of soil & ground water in these border villages and make them water & environment smart, an initiative towards their smart & sustainable development.

5.5 Evaluation on the basis of development

5.5.1 Swachh Bharat Mission-Gramin

The Indian government launched Swachh Bharat Mission; a community development initiative focused on the needs of the people. Various rural development schemes to spread awareness and improve upon the health and sanitation needs of the citizens.

Catering to the rural areas Swachh Bharat Mission Gramin (SBM-G) was started with an objective to provide toilet facility to every household in the villages. The main focus is to make the villages 100 percent ODF i.e. open defecation free. In the present study it was found 53% of the household in the surveyed villages had the toilet facility in their houses whereas 47% of the households did not have the facility and defecated in the open. The possible reason could be low level of education, lack of awareness & consciousness of environment, ignorance about health, hygiene and sanitation as well as low socioeconomic status (Bhattacharya, S., *et al.,* 2018). The findings were similar to the ones done earlier (Swain, P., & Pathela, S., 2016) where in a survey-based study, it was found that 76% of the population was not aware of such a programme being run by the centre in the villages for the rural masses and those who were aware (56%) did not give much importance to health, hygiene and good sanitary conditions. It was also observed that only 54% of the population in villages were using the toilet facility while 46% are still defecating in the open. In another study carried out on Swachh Sarvekshan survey data of SBM plan, the results indicated that for the successful outreach of such cleanliness drives factors like literacy rate, awareness, socioeconomic status and geographical locations play a very important role. (Bhattacharya, S., *et al.*, 2018). At present 50% of the villages have achieved the ODF Plus free status under phase II of the mission (pib.gov.in,2023). Thus, it is a long way to accomplish the target of making India ODF free by 2024-25.

As per another study done on the impact of SBM Gramin in the villages of Reasi district of Jammu and Kashmir it was found that on the basis of individual household latrines, the goal of delivering universal sanitation coverage has been achieved to certain extent, however open defecation is still a common practise in many areas. Further, it was noted that solid and liquid waste management, a crucial aspect of the Swachh Bharat Mission (Gramin), received no attention up till now. The central government programme of Swachh Bharat Mission to make India 100% ODF by 2019 or Sampoorna Swachh is not completely achieved. A joint monitoring programme (JMP) on water, sanitation and hygiene carried by WHO and UNICEF. The report released in July 2021 states that at least 15% of the total population of India still defecates in the open. To be more precise it is 1% of the urban and 22% of the rural population that practices open defection in country.

5.5.2 Border area development scheme (BADP)

This scheme, which only serves the border regions of the nation, is active in seventeend ifferent Indian states that border other countries. Funds from the central government's spontaneous programme are used to support the progress and development of residents in the border states. Typically, BADP funds are utilised to fill significant gaps and meet the immediate needs of the border area dwellers. Planning and execution of BADP initiatives should follow the government directives, should be participatory in nature and decentralised through Panchayati Raj institutions or autonomous councils or local bodies. In the present work it was found that the BADP fund allocation was maximum in the year 2017-18 in all the border districts except Tarn Taran and Pathankot where these funds were maximum in the year 2019-20. Another trend was seen that minimum funds under this programme were allocated in the year 2016-17 in all the border districts. On an average each district received nearly 25% share of the allocated funds in the tenure of these five years but district Pathankot received 30.65% during the same time period. In year 2017-18 the maximum funds released to all the six border districts of Punjab are in the order; Ferozepur 23.3% > Amritsar > 21.1% > Fazilka 18.6%, 17.2% Tarn Taran >14.25% Gurdaspur > 5.03% Pathankot. As per the guidelines of BADP the funds are allocated on the basis of three parameters i.e. population, area in sq. kms. and international border length in the border block and border district. An overall view shows that every year the same pattern has been followed while allocation of funds. Funds have not been utilised or allocated to generate alternate sources of income by creating job opportunities or skill development programmes for youth. Funds are spent on infrastructure etc. which can be done under other schemes also (Niti Aayog, 2015). During the survey it was observed that people are not much satisfied with the developmental works done in villages under this programme. The data from the concerned department reveals that work is done for making rest shed with toilets or waiting halls for the farmers who come to tend their fields during the field visit hours. Moreover, coordination of BADP programme with other State or Centre run programmes seems to be lacking which is similar to a study done earlier (Vaishnava, P. and Kannan, M., 2018). In a similar study in Rajasthan, it was found to have lower rates of female participation in the organising and carrying out of events than other states. From 2010 to 2015, the amount spent only changed by 40.75% to 61.41%. There have been incidents of the Rajasthan government delaying the delivery of federal funds to entities who implement them, diverting money, and failing to coordinate the Border Area Development Programme with State and federal programmes. Overall, the residents of the state were not much happy with the developmental works done under this programme (Vaishnava, P. and Kannan, M., 2018).

The data from the above survey shows 53% of the household in the surveyed villages had the toilet facility in their houses while 47% of the households did not have the facility and defecated in the open. The possible reason could be low level of education and less availability of high schools, good infrastructure, lack of awareness & consciousness of environment, ignorance about health, hygiene and sanitation as well as low socioeconomic status (Bhattacharya, S., *et al.,* 2018). Also, the policy of fund allocation under rural development schemes in these villages needs improvement. People are not aware of such programmes and are not happy with the development works. Many developmental aspects are still not the target of development and sustainability. The BADP funds should be utilised in those developmental areas that are not covered under other developmental schemes.

5.5.3 Status on the basis of development indicators

From the survey of the villages on the basis of development indicators, the results are shown in Table 5.2 as follows:

Table 5.2: Development-wise list of border villages of Punjab as per indicators

S. No.	District	Most Developed Village	Least Developed Village
1	Pathankot	Khojke Chak	Datyal
2	Gurdaspur	Jaurian Khurd	Thundi
3	Amritsar	Bhakna Kalan	Ranian
4	Tarn Taran	Kalia	Manakpur
5	Ferozepour	Mamdot hithar	Hazara
6	Fazilka	Asafwala	Muhar Jamsher

Majority of the villages in district Tarn Taran have indicator score up to 14 (66.7%) while in others it is above 14 (33.3%). Here, good literacy rate, high income group, good size of landholdings has been observed in district Tarn Taran. Here a good percentage of population is healthy population and have moderate environmental awareness. Overall Village Kalia in District Tarn Taran is the most (A Grade) developed with respect to development indicators and village Muhar Jamsher in District Fazilka and village Thundi in District Gurdaspur are the least (C) developed villages in the area under study. Village Muhar Jamsher in district Fazilka is less developed due to its unique fence-locked location making it inaccessible and insecure while Village Thundi is also very close to the international border hence poor developmental status.

All the villages in district Pathankot have development indicator score below 7, thus comprising of poorly developed villages.

From this study it has been found that low level of education, poor socioeconomic status, lack of environmental awareness and consciousness are inter-related and are important in development. There are many issues and challenges that have been mentioned in the text which the people face. If people are well educated and have good socioeconomic profile, they would better understand the importance of environment & sustainable existence and hence play a pivotal role in the environmental appraisal of the villages.

CHAPTER 6

SUMMARY

Borders are defined as political boundaries that separate the countries, states or provinces. It outlines or defines an area or a political entity that is governed by a particular set of laws. Punjab state shares its international border with Pakistan and has a long stretch of 553km. Out of the total 29 districts six districts of the state share the international border with Pakistan. These districts are Amritsar, Gurdaspur, Ferozepur, Fazilka, Pathankot and Tarn Taran. As the two nations share a little hostile relation and due to decade long cross border terrorism these border districts lag behind in various developmental aspects. Being very close to the Radcliffe Line, many villages in these border districts are far behind their counterparts in the non-border areas. Apart from the above stated reasons, restricted visiting and working hours for farmers in the fields, inaccessibility as well as security reasons, as a result several areas in this special zone have not progressed much. These villages are sparsely populated as people live under several kind of psychological strains & stresses. These areas also suffer from socio-economic and environmental problems. Thus, it became necessary to take a comprehensive look into the different aspects of these special geographical pockets of Punjab and apprise their environment.

In the year 2014, Central government launched a programme SAGY i.e. Sansad Adarsh Gram Yojana on the principles of the father of the nation Mahatma Gandhi who said that village is the basic unit of development and India lives in its villages. It becomes necessary to develop the Indian villages in a holistic way for the better accomplishment of various Sustainable Development Goals (SDGs) with special focus on social, economic and environmental aspects. If these three pillars of sustainability are strong only than an area or an entity is said to be SMART and developed. It is the fundamental right of all the citizens irrespective of the area of habitation, rural or urban to have an access to basic facilities like education, health, sanitation, portable drinking water, transportation, good roads, hygiene etc.in order to lead a progressive life with better income prospects, employment opportunities and a good standard of living. Rural development in the real sense caters to improving the living standard of the rural inhabitants in all these basic aspects of life and fulfil their needs and demands. On a similar pattern the concept of SMART Village was initiated world-wide. The objective was to develop the villages by providing all the basic facilities/amenities and make them self-reliant entities.

To improve life and make rural areas progress, several rural development programmes or flagship schemes are regularly launched by the Central and State Government. It becomes all the more important to assess the effective implementation and evaluation of such people-oriented schemes. One such scheme that is specially meant for the border area is Border Area Development Programme (BADP) – A central sector scheme that caters to the needs of the inhabitants living in the border zone by complementing the State Plan Funds. The objectives are to fill in the gaps in the socioeconomic infrastructure as well as enhance the security situation in border areas. BADP is a significant intervention of the Central Government that brings about development of border areas with the support of Central/State/BADP/Local programmes.

Another mission of the father of the nation was to make India a clean India. A flagship scheme initiated by ministry of Jal Shakti is Swachh Bharat Mission or Clean India Mission. The programme was started in two phases with a basic objective to eliminate manual scavenging, bring behavioural change towards health, hygiene & sanitation and to increase general environmental awareness among the masses. Swachh Bharat Mission (Gramin) an extension of SBM designed for the rural areas with the objective to make India open defection free (ODF) and enhance solid liquid waste management as per the target of SGD-6.

For a village to be smart, it is not only the infrastructure and basic amenities that matter but environment is an integral part of sustainable development. Agriculture is the primary sector of employment and major source of income. It depends on quality of soil and water. Both being vital component of environment, it thus becomes important to evaluate the quality of soil and water that is pivotal for cultivation of crops. A significant increase in population and a growing demand for food grains has led to the widespread application of agrochemicals, fertilisers, fungicide, weedicides etc. in agriculture. Industries & industrial effluents have contributed in disturbing the structure and composition of soil and water. All such anthropogenic activities have contaminated soil and water with heavy metals and metalloids.

Farmers have been using the various chemical-based fertilisers in their fields to enhance the productivity of the crops. Being illiterate and less educated, they are ignorant of the harmful effects of agro-chemicals and the importance of clean and green environment in the life.

The current study has been undertaken with these objectives:

- Monitoring of various environmental and socio-economic issues
- Assessment and monitoring of soil and water quality and heavy metal analysis.
- Analysis of Local problems of the villages under study.
- Evaluation of villages based on development and under various development schemes.

The area under study was surveyed extensively and 34 villages were chosen randomly from the six border districts of Punjab, situated along the international border i.e. Amritsar, Gurdaspur, Tarn Taran, Ferozepur, Fazilka and Pathankot. From each village primary data was collected through group discussions, interviews and questionnaires. The villages were surveyed with the help of the local residents to have a first-hand report of the various issues and challenges which they face, development status etc. for their environmental appraisal. At the same time the villages were also evaluated for the rural development schemes-Swachh Bharat Mission (Gramin) and Border Area Development Programme for their effectiveness in the villages. All the data so collected was compiled for further analysis which was done using descriptive statistical analysis. Further from each village, water and soil sampling sites were selected randomly from where groundwater and municipal water samples were collected. In all, 34 groundwater as well as drinking water samples (triplicates) were collected and similarly 34 composite samples of soil were collected from the same geographical locations.

Soil samples were subjected to physico-chemical parameter analysis such as pH electrical conductivity (EC), soil texture, bulk density (BD), moisture content (MC), soil organic carbon (OC), soil organic matter (SOM), content of nitrogen (N), phosphorus (P), potassium (K) and magnesium (Mg) and sulphates (SO^-_4) using standard methods. Similarly, groundwater and municipal water samples were analysed for physico-chemical parameters such as pH, EC, total hardness (TH), total alkalinity (TA), Total Dissolved Solids (TDS), fluoride (F^-), chloride (Cl^-), nitrate (NO^-_3) and sulphate (SO^-_4) ions. These soil and water samples were further subjected to heavy metal analysis such as selenium (Se), cadmium (Cd), chromium (Cr), lead (Pb), nickel (Ni), Iron (Fe), uranium (U). Descriptive analysis and Pearson Correlation Matrix was carried out to draw inferences from the data.

The key findings from this study can be summarized as follows:

Basic amenities: They form a very important aspect of the development and progress of a community. In the present study it has been found that 85.2% of the villages under survey had accessibility by all-weather metalled roads. In India only 33% of the rural communities have a rural road network. 73.5% of the streets and drains are cemented or interlocked but majority of the drains are still uncovered and non-cemented. This makes the village environment unhygienic & unhealthy, thus exposing the villagers to a number of airborne and waterborne infections and diseases. Sanitation conditions are a little better and available in villages but this sector needs more attention. The sports sector has been found to be under neglect in all the villages and a negligible percentage of this facility is available.

Majority of the people in the villages fall in the age group of 46- 55 years which can be correlated to the fact that rural youth is migrating to nearby towns and villages because of the lack of basic facilities like education, health & sanitation, remoteness and inaccessibility, in pursuit of better opportunities to earn a good livelihood. Although agriculture is the primary occupation of 46% of the villagers but none of the villages have been found to show any advancement in the agricultural practises. There is also lack of awareness and consciousness on safe use and over use of agro-chemicals, fertilisers, insecticide and pesticides etc. This has a direct relation with the level of education of the farmers as 87.6% of the farming community use excess of pesticides and fertilisers. Lack of formal education and training pertaining to agro-chemicals being and low level of education (29.4% matriculate), the farmers have an unscientific and non-standardised approach towards such agricultural practises including stubble burning (65.8%), dumping of waste and water (84.9%). The consciousness and awareness level of people and farmers towards environment is further evident by the fact that only 23.7% of the farmers practise crop rotation and diversification and very little percentage 6.4% of the farmers are aware of the significance of soil and water quality. As the average size of the land holdings is 1-4 acres (30.18%) and the larger population (32.9%) has a monthly income of Rs 5000/ so people often take money on credit money from the banks.

Soil analysis: In the current study the composition of soil was 14.1- 37.81% silt, 20.89 - 50.22% sand and clay content was 16.53 -60.37%. Nearly all the soil samples were of clayey loam type. The soil samples collected from the various locations selected for this study purpose were slightly alkaline in nature with pH in the range of 6.9 - 9.0. Electrical conductivity which is the measure of the salinity of the soil was in the range of 65 to 268.67 µS/cm which is well within the permissible limits. The moisture content of the soil which is one of the principal constituents for the growth of plants and helps in regulating the temperature of soil was found in the range of 4.35 to 24.9% and the mean value was 13.183%. A positive correlation of EC with the soil organic carbon could be related to the clay loam type soil which has good water holding capacity thus it retains moisture for a longer time. Bulk density of the soil samples was also analysed which is an indicator of porosity and compaction of the soil. High bulk density means the soil is less porous with low compaction. There was a positive correlation between pH and bulk density (r= 0 .464). It was in the range of 0.79-1.283 g/cm^3 with the mean value of 1.043 g/cm^3.

Organic carbon refers to the carbon content of organic compounds and is the measurable component of the soil organic matter. It influences the biological, physical and chemical properties of the soil. The agriculture soil samples in the present study had organic carbon in the range of 0.25 -0.71% and the mean value was 0.424%. In the soil samples the soil organic matter which is the proportion of humus in the soil was found to be low and in the range of 0.43 -1.221 %. There was found a positive correlation between organic carbon and organic matter in the soil samples (r=0 .916).

The nitrogen matter of the soil samples under study was in the range of 15.33 -95.07 g/kg with mean value of 62.813 g/kg. It also showed a positive correlation between potassium and nitrogen content (r=0 .663) Thus soil nitrogen and potassium are directly correlated to either each other and if one of them increases the other one will also show an increase in its value. For strong roots and good fruit formation, phosphorus is very vital but the application of fertilisers has degraded and altered the soil properties. In the present study it was found to be low in the range of 4.233-25.877 g/kg with the mean value of 13.659 g/kg. There is a positive correlation between pH, bulk density (r=0.464), BD-N (r=0.486) and nitrogen and phosphorous (r=0.663) content of the soil and the values are significant at $p>0.05$. Potassium content in the soil samples taken up from the selected sites was found to be in the range of 36.57- 266.7 mg/ kg.

Heavy metal content: Soil is often subjected to a number of natural and anthropogenic activities but is a storehouse of heavy metals which are useful in minor quantities to the plants for their various life processes but excessive use of agrochemicals fertilisers, rapid industrialization has contributed to more heavy metal contamination in the soil. In the present study estimation of the contents of various heavy metals and metalloid i.e. selenium, cadmium, arsenic, lead, mercury, nickel, chromium, magnesium and Uranium was carried out in the agriculture soils. Arsenic content was found in the range of 0 .006- 0.08 mg/kg and well within the acceptable limits of 20 mg/kg.

Chromium is a toxic carcinogenic element harmful even in minute concentrations. The chromium content in the soil samples of the study area were well within the permissible and was not detected in 20.6% of the samples. It was in the range of 0.006-0.086 mg/kg. Another highly toxic heavy metal that disrupts the various bodily functions and interferes with the growth of plants is Lead. It ranged from 0. 010 -0.02 mg/kg and was well within the permissible limit. In 58.8% of the soil samples lead was not detected. The third toxic heavy metal that was analysed in the present study was cadmium which induces oxidative stress in the plants by disrupting the cellular enzyme functions. The mean concentration of cadmium was in the range of 0.003 - 0.02 mg/kg. It was not detected in 23.5% of the soil samples. Nickel content in the soil samples of the present study area was also estimated in the range of 0.003-0.086 mg/kg with mean value of 0.027 mg/kg and it was found to be well within the permissible limit. It was not detected at three locations sites taken up for study. Another metalloid estimated in the soil samples was selenium which is very important for the biological processes of animals and human beings. It was detected in the soil samples in the range of 0.01- 0.056 mg/kg with the mean value of 0.031 mg/kg. Uranium detected in the soil samples was in the range of 0.003-0.086 mg/kg. Mercury content in the soil samples of the study area was in the range of 0.0003-0.003 mg/kg and was not detected in 61.7% of the samples.

Water analysis: To evaluate the quality of drinking as well as groundwater, samples were taken from the 34 locations of study area. The various physico- chemical parameters as well as heavy metal estimation was carried out. Variables like pH, electrical conductivity, TDS, total alkalinity, total hardness, chloride, Fluoride, sulphate, magnesium and nitrate content were analysed. All the samples of both ground and municipal water were alkaline in nature and pH was well within the range with mean value 8.73 except at two sites where it was more than 8.5 at ZASF and FMMH. Different ions are present in the water and electrical conductivity is a good measure of ions. It not only gives taste to water and estimate its salinity and TDS. The groundwater samples had EC in the range of 105.6 – 859.6 µS/cm whereas municipal water samples had EC between 104.6- 832 .67 µS/cm. TDS was in the range of 150-825.6 mg/l in ground water while it was 110.0-642.0mg/l in municipal water samples. The mean value of TDS in groundwater samples was 368.9 mg/l and mean value for municipal water was 376.0 mg/l.

Total alkalinity of water is due to the presence of bicarbonate ions. The groundwater samples had a total alkalinity in the range of 153.3 – 553.3 mg/l with 97% of the samples had the values above the permissible limit whereas in municipal water it was in the range of 152.0-455.3 mg/l and 85.3% of the samples had alkalinity value above the permissible limit. The possible reason for high alkalinity could be the overuse of fertilisers and addition of carbonates and bicarbonates from soaps and detergents rich waste water used in household chores. Total hardness in groundwater was in the range of 103.0-381.0 mg/l whereas municipal water it was 105.3 - 368 .67 mg/l. A total of 47 % of the municipal water and 64.7% of the ground water samples had total hardness above the permissible limit of 200 mg/l making water hard.

The chloride content in groundwater samples was 0.50-38.96 mg/l whereas municipal water samples it was found to be 2.63 to 39.21 mg/l. None of the samples was found to have values higher than the permissible limit of 250 mg/l as given by Bureau of Indian standards, 2012. Similarly, the fluoride content in water samples was in the range of 0.01 to 1.567 mg/l in groundwater and 0.01- 1.16 mg/l in water municipal samples of the study area. The results showed that 14.7% of the samples of groundwater and 8.8% of the municipal water had fluoride content higher than the permissible limit of 1 mg/l. The nitrogen content in municipal water was 0.26- 21.66 mg/l while it was in the range of 0.167 to 36.03 mg/l in the groundwater samples. All samples had nitrogen content within the permissible limit.

Similarly, the sulphate content in municipal water was in the range of 6.13 to 218.54 mg/l while in the groundwater samples it was in the range of 13.89 to 232.87 mg/l respectively. The results showed that 14.7% of the municipal water and 17.6% samples groundwater had sulphate content above the permissible limit. The magnesium content in municipal water was quite above the permissible limit of 30 mg/l. Around 23.5% of the municipal water and 29.4% of the groundwater samples had magnesium content above the permissible limit. The possible reason for such high magnesium content would be the leaching of nutrients in the form of agricultural runoff and increased discharge of affluence from domestic waste.

Heavy metal analysis of groundwater and municipal supply water samples

All the groundwater as well as municipal water samples were further analysed for the presence of metalloid and heavy metal contents. For the present study arsenic (As), selenium (Se), iron (Fe), lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni) was estimated. The arsenic content in groundwater samples was in the range of 0. 001 to 0.03 mg/l whereas municipal water samples had arsenic content in the range of 0 .0001- 0.023 mg/l.

Selenium content in municipal water was in the range of 0.0001 to 0.005 mg/l while groundwater samples had selenium in the range of 0.0001 -0.026 mg/l. Almost 29.4% of the municipal water and 17.6% groundwater samples it was not detected. Another heavy metal taken up for estimation was cadmium. In municipal water, it was found in the range of 0.0001 - 0.003 mg/l whereas the groundwater samples showed cadmium in the range of 0.0001 - 0.0013 mg/l. Cadmium was not detected in 77.9% of the water samples and the content was well within the permissible limits.

The iron content in municipal water samples varied from 0 .001 to 0.028 mg/l. Iron content in groundwater samples was found in the range of 0.010 to 0 .056 mg/l and was well within the permissible limits. Lead content in 8.8% and 14.7% of the groundwater and municipal water samples respectively was not detected and was well within the permissible limit of BIS of 0 .01 mg/l. The lead content in municipal water was 0 .0003 to 0 .01 mg/l while it was in the range of 0.0013 to 0 .03 mg/l in ground water samples.

Chromium content was in the range of 0.0001 to 0.001 mg/l in groundwater samples and 0.0001 to 0.002 mg/l in municipal water samples. All values were well within the permissible limit. Chromium was not detected in 64.7% of the water samples taken up from various locations of the study area. The content of nickel was found to be well within the permissible limit in the water samples. It was not detected in 29.4% of the ground samples and 44.11% of the municipal water samples. It was in the range of

0.001 to 0.013 mg/l in municipal water samples while it was in the range of 0.001 to 0.023 mg/l in ground water samples.

Uranium was found in nearly all the water samples and was well within the permissible limit of 0.03 to 0.06 mg/l as given by BIS. It was in the range of 0.004 to 0.03 mg/l in groundwater samples and 0.003 to 0.02 mg/l in municipal water samples.

Local issues and challenges

The selected villages under study were also analysed for the various challenges and issues experienced by their residents. During the survey, several problems came to the forefront. The primary and most pressing challenge faced by the people is the absence of primary health centres or dispensaries and access to clean piped drinking water, a concern affecting 38.23% of the villages. Another notable issue concerning village environment and sanitation is the inadequate drainage and sewage systems, impacting 29.4% of the villages. Poor connectivity through all-weather roads presents a significant challenge, affecting 26.5% of the villages. Inadequate road infrastructure hampers the transportation of essential goods to these villages, depriving them of necessities that other villages enjoy. Another vital sector with multiple issues that faces neglect is education, particularly the condition of schools. Approximately 23.53% of the villages encounter various school-related problems. Subpar schools and inadequate educational infrastructure contribute to a low literacy rate, with nearly 50% of the population illiterate or below matric, in the surveyed villages. Additionally, villages situated near the border or zero line get irregular and insufficient compensation for crop loss, impacting 35% of these communities.

Rural development schemes

The Border Area Development Programme (BADP) is a region-specific initiative designed exclusively for the border areas of the country, encompassing 17 districts nationwide. Its primary objective is to bridge significant gaps and address the needs of residents in these border regions. In the course of this study, it was observed that minimal funding was allocated to all the border districts of Punjab in the year 2016-17, while the maximum funding was disbursed in 2017-18, except for the districts of Pathankot and Tarn Taran, where the highest funds were allocated in 2019-20. This analysis covered a five-year span, from 2015-16 to 2019-20. In 2017-18, fund allocation in the six districts were in the sequence, from highest to lowest: Ferozepur

> Amritsar > Fazilka > Tarn Taran > Gurdaspur > Pathankot. There was limited coordination between BADP and various other central and state-run programs, and overall, the population expressed dissatisfaction with the developmental efforts carried out under the BADP initiative.

Another rural development initiative undertaken was the Swachh Bharat Mission Gramin, a community-oriented program aimed at raising awareness and enhancing the health and sanitation conditions in various communities. The primary goal of this effort was to achieve 100% open defecation-free status of the villages.

In the current study, it was determined that 53% of households in the surveyed villages possessed indoor toilet facilities, while 47% did not and resorted to open defecation. This could be attributed to factors such as limited education and funds, insufficient awareness of environmental concerns, and a lack of knowledge regarding health, hygiene and sanitation. Additionally, all 34 randomly selected villages were subjected to thorough and comprehensive surveys, focusing on a range of developmental indicators. Based on these criteria, the villages were evaluated and analysed to identify prevalent challenges and issues faced by their residents, enabling a more comprehensive assessment.

A three-point scale was formed to evaluate villages based on the availability of developmental indicators. Villages with indicator values ranging from 0 to 7 were categorized as poorly developed, those with values between 8 to 14 were considered moderately developed, and villages with indicator values above 15 were classified as highly developed. The survey results indicated that in Districts Tarn Taran and Ferozepur, 33% of villages achieved an indicator score above 14. In District Gurdaspur, 25% of villages attained an indicator score above 14. In District Amritsar, 16.6% of villages achieved an indicator score above 14. Notably, in District Fazilka, no village scored above 14 on the indicator scale. In contrast, none of the surveyed villages in District Pathankot achieved an indicator score above 7. These findings suggest that villages in Districts Tarn Taran and Ferozepur are significantly more developed than those in Gurdaspur, followed by District Amritsar, and then Fazilka. The villages in District Pathankot were the least developed. One possible explanation is that for an extended period, District Pathankot lacked adequate connectivity with other parts of the state due to the absence of proper roads and bridges. These infrastructural deficiencies were only addressed from 2003 onwards, earlier the residents had to rely on makeshift bridges and waterways for transportation.

Conclusion

The observations of the study highlight the unfavourable socio-economic conditions prevalent in the surveyed villages. These villages can be categorized ranging from poor to moderately low in terms of development, with none of them displaying an above-average development level. Likewise, the examination of the environmental aspects within these villages indicates a concerning trend of soil and water quality deterioration. This degradation is marked by the detection of heavy metals such as arsenic, nickel, chromium, uranium, and others. These findings have significant implications both on the health and the environment. These villages collectively lack adequate environmental and sanitation amenities, including drainage systems and access to clean drinking water. Additionally, their medical and healthcare services are below average. The improper disposal of solid and liquid waste in open environment puts both children and adults at a heightened risk of water and airborne infections. Agriculture serves as the main occupation for these villagers, and the study has underscored the lack of awareness among farmers regarding use of agro-chemicals, modern and green farming techniques, including the utilization of renewable energy for irrigation. Government agencies should regularly arrange camps and workshops aimed at training farmers, enhancing their knowledge of field-related practices, and promoting awareness of the health risks associated with chemical fertilizers and pesticides. Farmers should be incentivized to adopt biofertilizers and biopesticides, embrace crop rotation and diversification, and adopt water-efficient crop cultivation methods. These measures will contribute significantly towards improvement of soil & water quality, the village environment and at the same time safeguarding the health of its residents.

To enhance the execution and efficiency of rural development initiatives, it is recommended to conduct a baseline survey. This survey should assess the disparities in the socio-economic, environmental, and infrastructure aspects of these regions to prevent plan and fund duplication. Before allocation of funds (activity-wise or sector-wise), it is advisable to review annual reports. This ensures that sectors experiencing delays or neglect during a specific period receive priority attention like basic infrastructure especially good roads, good infrastructure in education and health care system. It is crucial to prioritize addressing the immediate and pressing requirements of the residents in the border area to integrate them into the mainstream. People participatory approach should be encouraged in development planning. To improve the standard of living and the socioeconomic status of these villages, skill development programmes and incubation centres should be developed to give better job opportunities to the youngsters and help them earn a better livelihood. The utmost priority should be accorded to the education sector, where numerous enhancements are required. This includes the provision of improved infrastructure and the recruitment of permanent, qualified teachers to reduce student-teacher ratio, enhance the quality of education, and decrease dropout rates in higher grades. Essential amenities and facilities should be extended to the residents of border villages. Additionally, efforts should be made to enhance accessibility to these remote areas by providing all-weather road connections with other parts of the state. To make the villages soil and water smart, the local fauna comprising of certain herbs, shrubs and trees like *Achyranthes sp., Ricinus sp., Morus alba, Dalbergia sp., Albizzia species* etc. which are known hyperaccumulators of heavy metals & are capable of phytoremediation should be conserved as well as grown as a control measure towards the quenching of heavy metals present in the soil/water samples. These measures aim to enable these isolated pockets of Punjab to achieve self-sufficiency, self-reliance, and fulfil the primary objectives of sustainable development, ultimately transforming them into truly smart villages.

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APPENDICES

Appendix 1

Questionnaire for village survey*

(* Reference-*Unnat Bharat Abhiyan - Village Survey Form*)

Name: ________________________________Sex:__________Age:_____________

1. Details of the family members?
   a) Boys b) Girls c) Men d) Women
2. What is your monthly income?
   a) Rs. 2000 to Rs. 5000 b) Rs. 5100 to Rs. 10000
   c) Rs. 11000 to Rs. 20000 d) Above Rs. 20000
3. What is your occupation?
   a) Agriculture b) Shopkeeper c) Job
   d) Labour e) others
4. What is your qualification?
   a) Matric b) 10+2 c) Graduate
   d) Post graduation e) Illiterate
5. Have you ever taken loan/credit? If yes, what is the source?
   a) Bank b) Relatives c) Money lender d) others
6. What is the source of drinking water?
   a) Hand pump b) Water supply c) Government tap d) others
7. Are the leaking tap/ motors repaired well in time?
   a) Yes b) No
8. How many hours do you get water supply daily?
   a) 2 hrs. b) 4 hrs. c) 6 hrs. d) whole day
9. Have you ever got the sample of drinking water checked for quality?
   a) Yes b) No
10. What do you use for increasing the fertility of soil?
    a) Fertilizers b) Manures c) Vermicompost d) Any other
11. Do you add pesticides or Insecticides? If yes, then mention the quantity?
    a) Recommended dose b) approximate dose
    c) always variable d) by experience
12. Do you practice stubble burning? If yes, why?
    a) Easy option b) General practice
    c) Rodents d) Cheap and best
13. What method do you adopt for field irrigation?
    a) Canal b) Drip
    c) Sprinkler d) Any other
14. Have you ever got the soil sample checked?
    a) Yes b) No

15. What is the method of disposing the household waste water (grey water)?

a) Open drain b) Sewage c) fields
d) Ponds e) Any other

16. Do you practice open-defecation?

a) Yes b) No

17. Do you have toilets at home, if yes then how many?

a) One b) Two c) None

18. Did you get any aid for making toilets from government?

a) Yes b) No

19. Do you use biogas or solar cooker for cooking?

a) Yes b) No

20. Which crop/crops do you grow?

a) Wheat b) Rice c) Pulses d) Mixed

21. How many hours of electricity supply do you get for homes?

a) 2 hrs. b) 4 hrs. c) 8 hrs. d) whole day

22. How many hours of electricity supply do you get for fields?

a) 2 hrs. b) 4 hrs. c) 6 hrs. d) 8 hrs.

e) whole day

23. What method do you adopt for agriculture?

a) Modern methods b) Traditional c) Mixed

24. Do you use solar panels for irrigation of fields?

a) Yes b) No

25. At what level do you get good quality of water?

a) 150 ft. b) 200 ft. c) 250 ft. d) 300 ft.

e) 350 ft.

26. Does government take any initiated towards overall sanitation and cleanliness of the village?

a) Yes b) No

27. Does the village have mother-child care centre?

a) Yes b) No

28. Where do you dispose the household waste?

a) Outside the houses b) Outside the village

c) Specific dumping site d) Door to door collection

29. Do you have any health issues?

a) Blood Pressure b) Diabetes c) Both a & b

d) Knee joint problem e) Liver issues

30. How many acres of agriculture land do you own?

a) 1<4 b) 5<10 c) 11<20 d) >50 e) No land

APPENDIX 2

Publications

1. *Sustainability at Border Villages of Punjab (India): A Critical Study on Initiatives and Practices* Current World Environment 16(1) DOI:10.12944/CWE.16.1.08, April 2021(UGC Care Journal)
2. *Border Villages and Rural Development – A Case Study of Punjab (India).* Innovations, Issue : Number 75, Dec;2023. Scopus indexed
3. Spatial Distribution of Heavy metals in Border Villages of District Amritsar, Punjab (India), Accepted in AIP Conference and Proceedings (Scopus indexed)
4. Book chapter: *Biochar for sustainable Crop Production* in a book Titled "Sustainable Valorization of Agriculture & Food Waste Biomass" pp 227-256. Springer Publications, 2022.

Conferences Attended / Paper Presentation

1. Attended an International Conference on Recent Advances In Health Sciences from 14-15 April 2023 held by LPU, and presented a paper (under publication process).
2. Attended and presented a paper at 26th Punjab Science Congress, National Conference held by Sri Guru Granth Sahib World University, Fatehgarh Sahib, (Punjab) and published in Abstract Volume on February 07-09, 2023.
3. Presented a paper at 2nd National Research Scholar meet at Guru Granth Sahib World University Fatehgarh Sahib, (Punjab) on 15-16 March 2021.

Workshops Attended

1. Attended a One-week Synergistic Training Program on Advanced Characterization Techniques on Chemical Scaffolding held at GNDU by NIT Warangal from 21/9/2022-27/9/2022.
2. Online Short-Term Course on Material Characterization: Analysis and Interpretation held during 23rd to 28th August 2021 held by LPU.
3. Attended a Two-day workshop on Biosensors for Monitoring Pollutants held on 29-30 Nov; 2019 at LPU.