



LOVELY
PROFESSIONAL
UNIVERSITY

**LIMNOLOGICAL AND PHYSICO-CHEMICAL STUDIES
OF WATER SAMPLES COLLECTED FROM PUNJAB**

Dissertation Report:

Submitted in partial fulfillment of the requirements for the degree of
Masters of Science in Zoology(Hons.)

Submitted by

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This is to certify that **Ms.MandeepSampla** (Regd. No. 11508802), have completed dissertation report entitled “**Limnological and Physico-Chemical Studies of Water Samples Collected from Punjab**” under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of her report has ever submitted for any other degree at any university.

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DECLARATION

I hereby declare that the project **entitled “Limnological and physico-chemical studies of water samples collected from Punjab”** is an authentic record of my own work. The work has been carried out at School of Biosciences and Biotechnology, Lovely Professional University, Phagwara, Punjab under the guidance of **Dr. Jibanananda Mishra**, Associate Professor, School of Bioengineering and Bioscience, Lovely Professional University, Phagwara, Punjab, India, for the award of the degree Master of Science in Zoology.

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INTRODUCTION

Water is one of the most abundant as well as ubiquitous components of the ecosystem. All the living beings rely on upon water for their life. It has been revealed that earth is the main planet which contains 70% water (Patil, Sawant, Deshmukh, 2012). In the modern era, because of spontaneous quick urbanization and industrialization, water bodies are utilized as dumping space for different sorts of wastes, for *e.g.*, sewage and contaminations from houses, enterprises etc.(Ranee, &Vasantha, 2010). These contaminations influence the physico-chemical and also limnological properties of water (Goel, 2000). The deteriorating water quality influences the creatures and plants of water in light of the fact that the life of oceanic creatures and plants directly or indirectly relies on upon the nature of water (Contreras *et. al.*, 2009). This has been a great concern from the ecological point of view. It is unnecessary to specify that if there is any disturbance in the ecological balance of water, then all the living life forms related with a similar will be influenced.

Population on the earth is under extraordinary hazard because of unexpected changes in the quality of water along with air and soil (Misra and Dinesh, 1991). Larger amounts of contaminants,*e.g.* organic matter in water sample of river have been reported to rise in biological oxygen demand (BOD) chemical oxygen demand(COD), suspension and waste matter (Kulkarni, 1997). Because of this change, the water becomes inappropriate for inhaling, sprinkling on plants and other uses(Hari, 1994).The status of water quality is directly related with its chemical composition and their concentrations. The main cause of contamination of surface and additionally ground water is because of the collection of wastes from industries and public (Gupta, 2009). Therefore, it must be necessary to check the nature of water before its use at regular intervals to prevent the arrival of water borne sicknesses through contaminated water (Basavaraja*et. al.*, 2011).

The importance of water to humans, food, and socio-economic well being of mankind is very significant. It is the need of life which supports all the activities of latter. Consequently, we can't accept any movement in our existence without water (Basavaraga*et. al.*, 2011). Rivers are the important components of the natural environment and have many values which include economic, aesthetic, ecological, water for consumption etc. Surface water is a lively system which contains living substances along with non-living, natural, inorganic, solvent and insoluble substances. Therefore, there are chances that the quality of water can be changed day-by-day because of changes in the

substances present in it, which would additionally change the equilibrium in nature (Ranee and Vasantha, 2010).

Due to mixing of untreated waste-water from different industries into the rivers, their quality will be upset. Because of contamination of water in the rivers firstly influences the physico-chemical properties, and after that it influences the community. Due to these changes, food web is gets disturbed which is destructive for individuals and their wellbeing. Because of contamination of river the uses of it's for various activities becomes less. In this way, it is important to check the quality of water and to calculate the further changes in the quality of water in future (Kauret.al., 1999).

The nature of surface water might be affected by natural as well as human activities. As natural water bodies have the ability to absorb and dilute the components of the effluents discharged from the industries, they are utilized to discard the waste-water. The dumping of effluents of low quality into the regular water bodies is unchecked, which brings about decrement of the quality of water (McBride, 2002).

There are many reasons for pollution of surface water. The main causes are the toxic chemicals, nutrients due to geogenic processes as well as due to human activities *e.g.*, effluents from industries and agricultural practices (Dinelli, 2012).

Following different physic chemical parameters are tested regularly for monitoring quality of water:

1. **Temperature:** A temperature is an objective estimation of hot or cold. It is measured by thermometer (Paul S. Welch, 1938). Its most normal unit is Celsius. It is an essential physical property of water since it controls the rate of numerous chemical reactions. As temperature influences the growth, reproduction and immunity of living beings, in this way, drastic temperature changes can be lethal to living beings.
2. **pH:** pH is a scale which is available in numbers used to tell the condition regarding the aqueous solution *i.e.*, whether it is acid or base. pH values fluctuates from 0 to 14 (Victor and Robinson, 1939). The pH estimation of any solution at 7 is considered as neutral. If the pH ranges from 0 to 7, it results in acidity of solution while if the pH values ranges from 7 to 14, it tells that the solution is basic in nature. pH is indirectly related to the corrosive nature, *i.e.*, if the pH is low or acidic, then corrosive nature will be high (Gupta 2009). Many variables impact the

- pH of water like temperature, (CO₂) carbon dioxide concentration, contamination and so forth.
3. **Hardness:** It is a measure of total concentration of ions present in the water. Water that has high mineral substance is said to be hard water (Patilet. *al.*, 2012).
 4. **Alkalinity:** It is a measure of capacity to neutralize the acids and its capacity to keep up the relative consistent pH. It is determined by titration strategies within the presence of methyl orange indicator and phenolphthalein indicator.
 5. **Dissolved oxygen (DO):** DO give an idea that how much oxygen is dissolved in a unit volume of water. It measures the capacity of water to support aquatic organisms. If there is depletion of dissolved oxygen in water sample this will indicate the presence of pollutants and hence pollution in that water sample (PremlataVikal, 2009).
 6. **Biochemical oxygen demand (BOD):** It is a biochemical strategy which decides the measure of oxygen required by aerobic organisms in the water sample to deteriorate the organic matter at specific temperature *i.e.*, 20 °C and the time taken for this test is generally five days. It is very essential test which tells about the biodegradability of any water sample.

Heavy metals are those components which stay in the water bodies for quite a long due to the fact that they don't deteriorate easily because of persistent nature (Arnason and Fletcher, 2003). Their concentration in water bodies increasing day by day as a result of different types of movements, for *e.g.*, runoff, draining or permeation and dumping of industrial wastewater (Soares, 1999). Substantial metals and other trace elements also form some part of water investigation for the discovery of physico-chemical properties. Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) is an analytical technique used for the determination of major, minor and trace elements. It is a sort of emission spectroscopy that uses the inductively coupled plasma to deliver energized atoms and particles or ions that produce electromagnetic radiations at wavelength normal for a specific component. However, small amount of substantial (heavy) metals are required by living beings for good wellbeing. A portion of the fundamental components is iron, manganese, nickel, cobalt, molybdenum and copper while in extremes they are exceptionally harmful to human wellbeing (Kabata-Pendias and Mukherjee, 2007). The main sink of heavy metals is soil which gets their approach to food chain through water, plants or permeates through soil into groundwater. Heavy metals lethality prompts different harms, for *e.g.*, exhaustion of mental procedures (Gaza *et. al.*, 2005), harm to

DNA (Jomova *et. al.*, 2011), blood structure (Di Gioacchino *et. al.*, 2008), skin (Burger *et. al.*, 2007), kidneys (Johri *et. al.*, 2010), muscle (Visnjic-Jeftic *et. al.*, 2010), heart (Otlés and Cagindi, 2010), and other basic organs for living life forms and people.

Heavy metals are getting significance among the inorganic contaminants on account of their non degradable nature and quickly aggregate through tropic level causing a deadly biological impacts, the utilization of heavy metals containing manures and pesticides in agriculture brought about weakening of water quality interpreting serious environmental problems posing risk on person and managing aquatic biodiversity. Thus, investigating these metals is necessary for protective evaluation of environment and human health specifically. Because of collection of the trace components in the oceanic environment poor health impacts are created on organic subdivisions, accordingly, specialists have been concentrating on computing the dangerous trace elements and allotting their sources in the aquatic ecosystem.

Limnological review includes the investigation of inland waters. It covers the biological, physical, chemical and different characteristics of lakes and different assortments of fresh water. Planktons are very sensitive to their environment and if there is little change in nature, this will bring about changes in the communities of planktons in terms of their presence, abundance and diversity. In this way, perception of planktons is an essential device for studying the contamination status of water bodies (Basu *et. al.*, 2010; Prabhakar *et. al.*, 2011). Since planktons are cosmopolitan in nature and reflect the healthy conditions of the water biological system. Consequently, investigation of planktons can be utilized as alternative tool to check the nature of water alongside the evaluation of physico-chemical parameters (Singh and Sharma, 2014).

Trivedy (1988) demonstrated the utilization of planktons to check the contamination status in various water bodies. The survival of living life forms rely on upon the nature of water, if there is accessibility of contaminated water for biota of aquatic ecosystem then their survival rate is less which thus influences the quality of water (Contreras *et. al.*, 2009).

Planktons are omnipresent part of aquatic system as they keep up the healthy condition and contamination free water (Khangarot and Das, 2009). In the freshwater ecosystems their number decreases to a great extent, because of pollution, dumping of non treated waste-water from industries (Revenga and Mock, 2000).

Various uses of rivers are truly weakened because of increased contamination. In this manner, it has turned out to be essential to examine the water quality of rivers and to predict future changes in water quality because of the developmental actions in the district.

This will help in giving early cautioning to downstream users about the poor conditions of the water. Such kind of work is being carried out by limnologists and researchers throughout the world, so that proper measures can be taken to enhance the water quality for different purposes.

Very limited work has been done on the water nature of stream Sutlej (Gill *et. al.*, 1993; Kauret. *al.*, 1999, 2002). Keeping this in view, current study have been undertaken to evaluate the level of pollution and contamination from different sites of the rivers Sutlej and Beas.

ABBREVIATIONS

DO: Dissolved oxygen

BOD: Biological Oxygen Demand

COD: Chemical Oxygen Demand

TDS: Total Dissolved Solids

TA: Total Alkalinity

TH: Total Hardness

EC: Electrical Conductivity

WASA: Water and Sanitation Agency

WHO: World Health Organization

USEPA: United States Environmental Protection Agency

CPCB: Central Pollution Control Board

ISI: Indian Standards Institute

ICMR: Indian Council of Medical Research

ICP-AES: Inductively Coupled Plasma Atomic Emission Spectroscopy

REVIEW OF LITERATURE

There are not many, however some studies on few parameters of the water quality in the water samples collected from various sites of the Sutlej River and Beas River, have been conducted by some workers.

Physico-chemical properties of water collected from Sutlej River around Ludhiana area from three distinct sites (Ropar Head Works-**S1**, BudhaNallah at Phillaour-**S2** and BudhaNallah in region Ludhiana-**S3**) has been reported by Jindal and Sharma (2010). This study demonstrated low estimations of biological oxygen demand (BOD), total dissolved solids (TDS), chlorides, turbidity, total alkalinity, nitrates, total hardness and phosphates at **S1** and **S2** in comparison with **S3**. Heavy metals like Lead (Pb), Zinc (Zn), Chromium (Cr) and Nickel (Ni) were recognized at **S2** and **S3**. The water quality index values at **S1**, **S2** and **S3** were reported to be 32.84, 51.01 and 132.66 respectively. Mean estimations of the parameters were matched with the global standards of WHO (World Health Organization), ISI (Indian Standards Institute, Govt. of India) and ICMR (Indian Council of Medical Research, Govt. of India) and investigated. Information in this report demonstrated that the water at stations **S2** and **S3** not fit for human use.

C. Sharma *et.al.*, (2013) examined about the plankton species varieties and population dynamics of phytoplankton and zooplankton alongside the description of its connection with hydrobiological or physico-chemical properties of river Sutlej at Ropar Head Works. They found that phytoplankton belongs to the families Chlorophyceae, Bacillariophyceae, Euglenophyceae, Cyanophyceae and Protozoa, Rotifera and Crustacea were incorporated into zooplankton. Rotifera from zooplankton and Bacillariophyceae from phytoplankton were most elevated in number and had highest diversity. The qualities computed with Margalef Richness Index, Berger-Parker Dominance Index, Simpson and Shannon-Wiener diversity indices. Their standards were higher during summer and post monsoon seasons because of ascend in temperature, pH, and richness of supplements. Kumar and Dutta (1991) recommended that species number was diminishing in winters and the causative operators for this were low temperature and light. In monsoon season number was lessening a direct result of diminishment in pH and DO, and higher turbidity. The physico-chemical parameters, *e.g.*, DO, BOD, nitrate, phosphate, pH, TDS, add up to alkalinity and aggregate hardness were under the range with reference to WHO and USEPA.

Sharma and Singh (2014) determined the contamination status of river Sutlej in various locales of Punjab on the basis of species diversity indices. They saw the plankton species

diversity from four destinations at River Sutlej (S1) at RoparHeadworks, (S2) downstream after the juncture with BudhaNallah, (S3) at Harike before the intersection with East Bein, (S4) at Harike before the conjunction with river Beas. The water samples were collected for progressive two years (November, 2009-October, 2011) on monthly basis. The plankton species diversity was watched and calculated with various species diversity indices that were Shannon Wiener species diversity index, Simpson index, Berger-Parker index, Margalef richness index. The outcomes demonstrated the higher values (4.11) of Berger-Parker index was at S3, Simpson index (0.72) at S1 and (0.16) at S3; Shannon-Wiener index (2.97) at S1 and (2.53) at S3; and Margalef richness index (4.85) at S1 and (4.11) at S3, while lower values of Shannon-Wiener Index (2.39) at S2; Simpson file (0.14) at S2 and Margalef index (3.67) at S2 were observed. This concluded that higher qualities at S1 and S3 demonstrated the healthy status of water and lower values at S2 and S4 brings about unhygienic status of water.

Arshad *et. al.*, (2014) checked the quality of surface water of river Korang, Pakistan. Locales chose for investigation of water quality were at Angoori Street, Phulgaran, Baheria golf city which were the principle branches of waterway Korang, Rawal Lake and WASA (Water and Sanitation Agency) filtration plant. They analyze the physico-chemical parameters of water alongside the identification of heavy metals. Their review indicated increment in contamination level in all inspecting destinations because of arrival of local waste, poultry waste, farming waste and solid waste specifically into the examining locales. They contrasted the estimations of parameters with WHO, PakEPA and USEPA standards and found that parameters, for example, DO TSS, COD, TA, and metals like lead and cadmium exceeded the permissible range limits. The two stations *i.e.* Angoori road and Rawal Lake contain more concentration of contamination than other destinations. Also, WASA filtration plant was working productively and effective in diminishing the contaminants in contaminated water and made it fit for drinking.

Recently, studies by Vinod Kumar *et. al.*, (2016) around twenty five parameters alongside the investigation of eight heavy metals from four sampling sites in an area between Beas and Harike towns for pre-monsoon, winter and post-monsoon seasons showed the water quality of river Beas, Punjab. In this work, changes in chemical oxygen demand (COD), biological oxygen demand (BOD), PO_4^{-3} , dissolved oxygen (DO), hardness, total dissolved solids (TDS), turbidity, NO_3^{-1} , alkalinity and compost related parameters were accounted for. They concluded that PO_4^{-3} had a positive connection with BOD, while turbidity and TDS were contrarily related with BOD.

Chughtai M. *et. al.*, (2013), determined the limnological characteristics and plankton diversity at D.G Khan Canal water situated at D.G Khan City, Pakistan. A review was completed to examine the occasional variations in limnological qualities and planktonic diversity of D.G. Khan Canal water as influenced with sewage at D.G. Khan, Pakistan. They collected water samples on month to month premise and estimate water light penetration, carbonates, bicarbonates, EC, specific gravity, temperature, boiling point, turbidity, sodium, surface tension, density, pH, DO, Free CO₂, alkalinity, chlorides, sharpness, hardness, total solids, total volatile solids and TDS. An assessment of biological parameters such as presence, abundance and diversity index of planktons was also done because quality of water is related with the diversity and density of planktons. They found about 39 genera of phytoplankton and 14 genera of zooplankton. Among phytoplankton, Chlorophyta include 12, Cyanophyta contain 08, Euglenophyta include 4, Chrysophyta consist of 11, Cryptophyta and Pyrrophyta contain 2 genera each. From 14 genera of zooplankton, 9 fall under Protozoan, 4 under Rotifers and 1 genus of Cladoceran. Add up to number of living beings was 616, out of which 523 were Phytoplankton and 93 were Zooplankton. The diversity index values for zooplankton ranged from 1.08 to 1.68, whereas for phytoplankton it varied from 2.53 to 2.99. As the value of diversity index for zooplankton as well phytoplankton was less than 3, it may be concluded that water quality of canal is barely fit for use.

Dutta and Verma (2010) analyzed the zooplankton of river Chenab at Akhnoor, Jammu. Qualitative analysis of zooplankton has demonstrated the presence of 16 species of Protozoa which includes *Diffugiaturbulata*, *D.oblonga*, unidentified *Diffugia*, *D. accuminata*, *D. lebes*, *D. corona*, *D. urocellata*, *Arcella spp.*, *Lesquereusiamodesta*, *Lesquereusiaspiralis*, *Nebela spp.*, *Centropyxisecornis*, *C. constricta*, and *Phacus spp.*, 1 species of arthropod Crustacea i.e., *Diaptomus spp.* and 1 species of porifera is spicules of *Eunapiouscarteri*. On the other hand, quantitative dominance order was viewed as Protozoa (2-13 n/L) > Porifera (0-2 n/L) and > arthropod Crustacea (0-1 n/L). Because of quick turbulent stream; cool water, having a thin yearly variety in water temperature; wide vacillations in water release, nonappearance of pool in upper catchment and absence of macrophytic vegetation, zooplanktonic diversity and density in the river Chenab is low in contrast with the other lotic water bodies of the state. Examination of coefficient of correlation (r) of zooplankton with various qualities of water was insignificant.

Hanaa *et. al.*, (2000) determined the presence of heavy metals in drinking water and their effect on human health. They selected some of the cities of Egypt for the analysis of water

sample. As many individuals have experienced the diseases since last 20 years or so, it is necessary to elucidate the connection between drinking water and chronic diseases. There is a strong relationship between the drinking water polluted with heavy metals such as cadmium(Cd), molybdenum(Mo), lead(Pb), copper(Cu), chromium(Cr) and nickel(Ni) and chronic diseases for e.g., Liver cirrhosis, chronic anaemia, renal failure and hair loss. These heavy metals have been found to have relationship with a particular disease. Pb and Cd have shown to have link with renal failure, hair loss has been found to be due to Ni and Cr, chronic anaemia is related to Cu and Cd and liver cirrhosis is caused because of presence of Cu and Mo. After proper investigation of particular areas it has been found that the main reason for this abnormal condition was industrial waste and other agricultural activities due to which dangerous and harmful materials were discharged into the groundwater and in this way prompted the pollution of drinking water these zones(Hanna *et. al.*, 2000).

Jindal and Sharma, (2011) reported the qualitative and quantitative analysis of planktons at three sites, (S1- RoparHeadworks), (S2- BhudhaNallah at Phillaur) and (S3- BhudhaNallah in district Ludhiana). About 41 species of zooplankton and 43 species of phytoplankton were reported. Quantitative analysis was done with Simpson and ShannonWiener species diversity indices for all sampling sites. The order of diversity of planktons was $S1 > S2 > S3$, whereas for their abundance the order was $S2 > S1 > S3$. They also monitor the pollution status and found that S1 was oligomesosaprobic, S2 was mesopolysaprobic and S3 was polysaprobic. They studied that there were some species which were designated as bioindicators of pollution. Those species were *Ankistrodesmusfalcatus*, *Chlamydomonas sp.*, *Euglena viridis*, *Chlorella vulgaris*, *Spirulina sp.*, *Naviculacryptocephala* and *Synedra ulna* among phytoplankton and forms such as *Bodo sp.*, *Colpoda sp.*, *Daphnia pulex*, *Tubifextubifex*, *Aspidisca sp.*, and *Rotariarotatori* were found to be tolerant to polysaprobic condition. On the basis of data given by PCPB, they concluded that water at S1 was between 'A-B', at S2 was 'B-C' and at S3 was 'D-E' as shown in Table 1.

Designated-best-use	Class of water	Criteria
Drinking water source without conventional treatment but after disinfection	A	Total coliforms MPN/100 ml shall be 50 or less pH between 6.5 and 8.5 Dissolved oxygen 6 mg/l or more Biochemical oxygen demand 5 days 20°C 2 mg/l or less
Outdoor bathing (organized)	B	Total coliforms MPN/100 ml shall be 500 or less pH between 6.5 and 8.5. Dissolved oxygen 5 mg/l or more Biochemical oxygen demand 5 days 20°C 3 mg/l or less
Drinking water source after conventional treatment and disinfection	C	Total coliforms MPN/100 ml shall be 5,000 or less pH between 6 and 9. Dissolved oxygen 4 mg/l or more Biochemical oxygen demand 5 days 20°C 3 mg/l or less
Propagation of wildlife and fisheries	D	pH between 6.5 and 8.5. Dissolved oxygen 4 mg/l or more Free ammonia (as N) 1.2 mg/l or less
Irrigation, industrial cooling, controlled waste disposal	E	pH between 6.0 to 8.5 Electrical conductivity at 25°C $\mu\Omega/cm$ Max. 2250
	Below E	Not meeting A, B, C, D, and E criteria

Table1: Classification of water on the basis of uses.*Source:* Central pollution control board(www.cpcbnc.in/classi.htm)

SCOPE OF THE STUDY

For a healthy life every organism needs toxicant free and oxygen rich water. Majority of our water bodies seems to be polluted because of several reasons such as industrialization, increased population and man-made exercises. There are many substances and heavy metals which are invisible to us may contaminate the water bodies. Therefore, it is always essential to check the water quality at a regular interval to ensure its purity. Investigations on limnological and physico-chemical parameters can depict whether or not water is fit for drinking and other uses.

OBJECTIVES OF THE STUDY

In this review, I have discussed about the physical and chemical properties of water and its impact on living organisms. Water bodies are degraded because of industrialization, expanded population, utilization of manures, man-made exercises and natural contamination of trace elements like heavy metals, radioactive isotopes, *etc.* Because of this degradation of the water, its functions get modified which eventually influence the ecological balance in many ways. The goals of conducting the physico-chemical and biological investigations of water bodies are as per the following:

1. To review those chemicals whose presence can cause harm to aquatic animals, plants, livestock and human beings.
2. To study the impacts of these physical and chemical parameters on the biological community.
3. To know about the status of water bodies by studying their physico-chemical and natural parameters.
4. To review the qualitative details of living life forms in the water bodies in light of the fact that the biological stability of the water bodies keeps up the ecological functioning.
5. To check the concentrations of different elements, for *e.g.*, major, minor and trace elements along with heavy metals.

MATERIALS AND METHODS

WATER SAMPLE COLLECTION

SITE: Punjab is agriculture rich state and prosperous in its livelihood simply because of the five rivers (Sutlej, Beas, Ravi, Chenab and Jhelum). The Sutlej and Beas rivers are the longest streams touches upon a vast area of the state. River Sutlej is originated near the Mansrowar-lake in Tibet. Through the Himalayan valleys, it goes into Punjab, India through Kinnaur district. Further routed through the Nangal, it reaches the fields of Ropar and Ludhiana. On the other hand, it joins with river Beas at Harike and goes through Pakistan (Jindal, 2010). River Beas starts in the Himalayas in central Himachal Pradesh, India, at 31.51' N lat., 77° 05' E long and height 2050 m above ocean level, and flows for about 470 km to joins the river Sutlej. This river has an extensive variety of development alongside rural fields and t1he towns around the waterway Beas utilized it as a dumping source for disposal of waste materials (Kumar 2016).

In this way, I choose these two rivers and the samples were gathered from various locales of these rivers for my project.

Site 1: River Sutlej is located at RoparHeadworks (lat. 30°59'N; long. 76°31' 12"E; alt. 272m above m.s.l.) in Punjab.

Site 2: RiverSutlej downstream after the juncture with BudhaNallah. It is 95 km downstream S1, where BudhaNallah joins river Sutlej at town Wallipur (lat. 30°58'N; long. 75°37'49"E; alt. 228 above m.s.l.).

Site 3: Beas (31.510'N, 75.305'E and 211masl): Located in region Amritsar, the town is the head quarters of a religious order, RadhaSoami. Consistently, a huge number of explorers come to Beas (Kumar 2016).



Figure 1: Showing sampling sites S1, S2 and S3. (Adopted from Jindal & Sharma, 2011)

SAMPLING: The samples were collected from BudhaNallah on dated 19, February 2017; from Beas on dated 21, February 2017; from Ropar on dated 14, March 2017. Around 2000ml of water sample was collected from each site.

EQUIPMENTS USED:

Burette, Micro Pipette, Measuring cylinder, conical flask, Burette stand, Beakers, Thermometer, pH meter machine, BOD conical flasks,

CHEMICALS REQUIRED:

Ammonium chloride, N/50 sulphuric acid, Erichrome Black -T indicator(EBT), Ethylene diamine tetra acetic acid (EDTA), Ammonium hydroxide, Magnesium sulphate, Manganoussulphate, Potassium hydroxide, Potassium iodide, Alkaline-Iodine-Azide reagent, Sodium thiosulphate stock solution(0.1N), Sodium thiosulphatetitrants(0.025N), Starch indicator, Sulphuric acid, Phenolphthalein indicator, Water sample, Dilution water.

PREPARATION OF CHEMICALS:

EBT indicator- Dissolve 0.5gm Erichrome Black -T indicator in 100ml of distilled water.

EDTA – Dissolve 2.9gm Ethylene diamine tetra acetic acid (EDTA) in 500ml of distilled water.

Ammonium Buffer Solution- 16.9gm of ammonium chloride (NH_4Cl) and 1.17gm of EDTA is dissolved in 143ml of ammonium hydroxide (NH_4OH) and diluted to 250ml with distilled water.

N/50 Sulphuric Acid- Mix 240 μl of concentrated sulphuric acid (H_2SO_4) in 500ml distilled water.

Phenolphthalein indicator- Dissolve 0.5gm phenolphthalein indicator in 50ml ethanol and add 50ml distilled water.

ManganousSulphate- 8.3gm of manganoussulphate (MnO_4S) is dissolved in 50ml distilled water.

Alkaline-Iodine-Azide reagent- Dissolve 1.5gm of potassium iodide (KI) in 1.5ml distilled water and 0.1gm of sodium azide (NaN_3) in 400 μl distilled water. Add 7gm pellets of potassium hydroxide (KOH) and make 10ml solution by adding distilled water.

Sodium Thiosulphate Stock Solution (0.1)- Dissolve 12.5gm of sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$) in 500ml distilled water.

Sodium Thiosulphate Titrant Solution (0.025) - Take 125ml of stock solution and make it 500ml by adding distilled water.

Starch indicator- Dissolve 1gm of starch in 50ml distilled water.

PREPARATION OF DILUTION WATER:

Mix 1ml each of phosphate buffer, magnesium sulphate, and calcium chloride and ferric chloride solution and make it 1000ml by adding distilled water.

Phosphate Buffer Solution- Dissolve 8.5 g potassium dihydrogen phosphate (KH_2PO_4), 21.75 g dipotassium hydrogen phosphate (K_2HPO_4), 33.4 g disodium hydrogen phosphate heptahydrate ($\text{Na}_2\text{HPO}_4 \cdot 7\text{H}_2\text{O}$), and 1.7 g ammonium chloride (NH_4Cl) in about 500 ml of distilled water and dilute to 1 liter.

Magnesium Sulphate Solution- Dissolve 22.5 g magnesium sulfate heptahydrate ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) in distilled water and dilute to 1 liter.

Calcium Chloride Solution- Dissolve 27.5 g anhydrous calcium chloride (CaCl_2) in distilled water and dilute to 1 liter.

Ferric Chloride Solution- Dissolve 0.25 g ferric chloride hexahydrate ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$) in distilled water and dilute to 1 liter.

METHODOLOGY: Different methods for the analysis of physico-chemical parameters of water samples are given below:-

1. **Temperature:** The temperature was measured by taking a portion of the water sample and immersing the thermometer into it for a sufficient time period and the reading is taken, which was expressed as °C.
2. **pH:** pH was measured with the help of pH meter by immersing a rod for a sufficient period of time so that the reading becomes stable.
3. **Hardness:** The purpose of this experiment is to determine concentration of ions present in the water. Following steps are followed to perform the experiment:
 - I. 100ml water sample was added in a conical flask.
 - II. Then 2ml ammonium buffer was added followed by few drops of EBT indicator.
 - III. Titration was done with EDTA(in the burette) until the colour changes from wine red to blue.
 - IV. The volume (ml) of EDTA solution used was noted.
4. **Alkalinity:** Alkalinity is a measure of ability of water to neutralize the acids and ability to maintain the constant pH (buffer). Its procedure has following steps:
 - I. 100ml water sample was taken in a conical flask.
 - II. 4 drops of phenolphthalein indicator were added and light pink colour appeared.
 - III. Titration was performed against N/50 sulphuric acid (in the burette) until light pink colour disappears.
 - IV. The volume(ml) of sulphuric acid used was noted.
5. **Dissolved oxygen (DO):** It measures the capability of water to support the living organisms present in water. Its procedure has following steps :
 - I. Watersample about 300ml was taken in a conical flask.
 - II. Then 2ml manganoussulphate was added well below the surface of water by means of pipette followed by 2ml sodium azide solution in the same manner.
 - III. Mix well till precipitations were starting appear. Leave for a few minutes to settle the precipitations.
 - IV. 2ml concentrated sulphuric acid was added so that precipitate gets dissolved.
 - V. Furthermore, 200ml sample was transferred into the conical flask.

VI. 2ml starch solution was added and blue colour appears in the solution.

VII. Titration was performed against 0.025N sodium thiosulphate (in the burette) until blue colour first disappeared.

VIII. The volume (ml) of 0.025N sodium thiosulphate used was noted.

6. **Biological Oxygen Demand (BOD):** This method is used to determine the amount of DO, the aerobic organisms used in the water sample to disintegrate or break the organic substances present in the given water sample at a certain temperature i.e., about 27°C over a five-day period. It has following steps:

I. Dilutions of water sample were prepared. I prepared 3 dilutions in the order of 40%, 60% and 80% so as to decrease the amount of oxygen dissolved in water sample by addition of dilution water.

II. Took diluted water samples about 200ml in separate conical flask and the initial DO was determined immediately by adding 2ml manganous sulphate well below the surface of water by means of pipette followed by 2ml sodium azide solution in the same manner.

III. Mix well till precipitations were starting appear. Leave for a few minutes to settle the precipitations.

IV. 2ml concentrated sulphuric acid was added so that precipitate gets dissolved.

V. Furthermore, 200ml sample was transferred into the conical flask.

VI. 2ml starch solution was added and blue colour appears in the solution.

VII. Titration was performed against 0.025N sodium thiosulphate (in the burette) until blue colour first disappeared.

VIII. The volume (ml) of 0.025N sodium thiosulphate used was noted.

IX. After the incubation period i.e. five days final DO was determined.

7. **Limnological analysis:** It includes the qualitative analysis of planktons present in the water sample. It was done with the help of microscope by putting a few drops of each water sample on slide and covered with cover slip. After that observed under the microscope and species were identified.

8. **Trace elements:** All measurements were performed on the Agilent Liberty 100 Inductively Coupled Plasma Atomic Emission Spectrometer, controlled by an IBM Personal Computer PS/2 Model 30/286. Both instruments have a 40.68 MHz RF Generator and a 0.75 m Czerny Turner Mono-chromator with 1800 grooves/mm

Holographic grating. An argon saturator is standard. This instrument was chosen for its excellent resolution and stray light performance.

Sample preparation: Water samples were filtered and acid stabilized soon after collection. A 200 ml aliquot of a well-mixed, acid preserved sample was transferred to a beaker. 20 ml of concentrated HCl was added to the sample. The sample was heated (not boiled) on a steam bath until it was evaporated to near dryness. The beaker was rinsed thoroughly with 10% v/v HCl solution and the contents were transferred to a 20 ml volumetric flask and made up to the mark with 10% v/v HCl solution and then analysis was done with spectrophotometer.

RESULTS AND DISCUSSION

The present study was carried out to determine the physico-chemical and limnological studies along with the estimation of trace elements and heavy metals from different sites of Sutlej and Beas rivers. **S1** was BhudhaNallah, **S2** was Beas River at Harike and **S3** was RoparHeadworks. All the parameters were within permissible range according to WHO, ISI, ICMR, USEPA and CPCB.

Table 2: Physico-chemical parameters of water samples from **S1**, **S2** and **S3**.

Sample	Temperature			pH			Hardness			Dissolved Oxygen(DO)			Biologica Oxygen Demand(BOD)		
	Readings	Mean	S.D	Readings	Mean	S.D	Readings	Mean	S.D	Readings	Mean	S.D	Readings	Mean	S.D
Sample1	23°C	22.6°C	22.6±0.58	6.93	6.9	6.9±0.02	264	232	232±28.5	21.5	22.33	22.33±3.33	17.5	7.84	7.84±8.87
		22°C		6.88			210			26			6		
		23°C		6.9			222			19.5			0.025		
Sample2	22°C	22°C	22±1	7.49	7.48	7.48±0.04	166	166.3	166.3±1.53	6	5.87	5.87±0.42	15	9.55	9.55±5.25
		21°C		7.44			168			5.4			9.16		
		23°C		7.52			165			6.2			4.5		
Sample3	24°C	23.6°C	23.6±1.11	7.29	7.3	7.3±0.02	92	94	94±5.29	22.8	25.1	25.1±2.35	13.25	7.86	7.86±5.32
		22°C		7.3			100			25			7.71		
		25°C		7.33			90			27.5			2.62		

Table 3: Drinking water standards as per WHO, ISI, ICMR, CPCB and USEPA.

parameters	WHO	ISI	ICMR	CPCB	US EPA
temperature				>40	
ph	6.5-8.5	6.5-8.5	7-8.5	6.5-8.5	7
total hardness	500	300	600	600	
total alkalinity	200	-	120	600	200
DO	5		3 4 to 6		6
BOD	5		-		

1. **Temperature:** It is an essential physical property of water since it controls the rate of numerous chemical reactions. It also has impact on the development and distribution of plants and animals. If there is availability of plenty of nutrients along with high temperature, it supports the growth of algae and weeds (Welch, 1952). The temperature was found around 22.6°C, 22°C and 23.6°C at S1, S2 and S3 respectively. Analysis shows that temperature was high at S3 as compared to S1 and S2 and within the permissible range when compared with CPCB and thus water is potable for use.

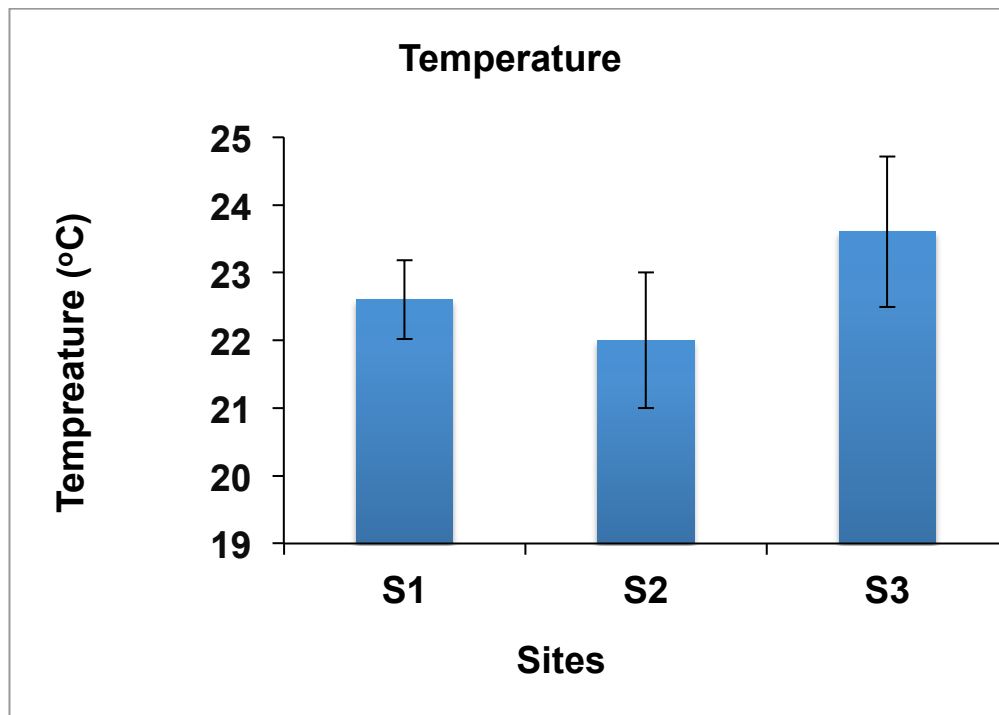


Figure 2: Histogram showing temperature variations of water samples from sampling sites.

1. **pH:** pH indicates the acidic and alkaline conditions of any solution. pH is affected by various factors such as temperature, CO₂ concentration and pollution. High temperature in water bodies lead to formation of carbonic acid (H₂CO₃) due to dissolution of CO₂ in H₂O at higher temperature ranges. Then reduction of this carbonic acid results in raising pH of water bodies. High pH helps to maintain the productivity of water body (Kamalkanthe *et al.*, 2012).

Krishnamet. *al.*, (2007), demonstrated that pH range from 6.7 to 8.4 was found to be safe for aquatic organisms, pH less than 4.0 and more than 9.6 is dangerous to living beings. pH values at all three sites are within permissible limits and therefore water is fit to use for drinking and other purposes.

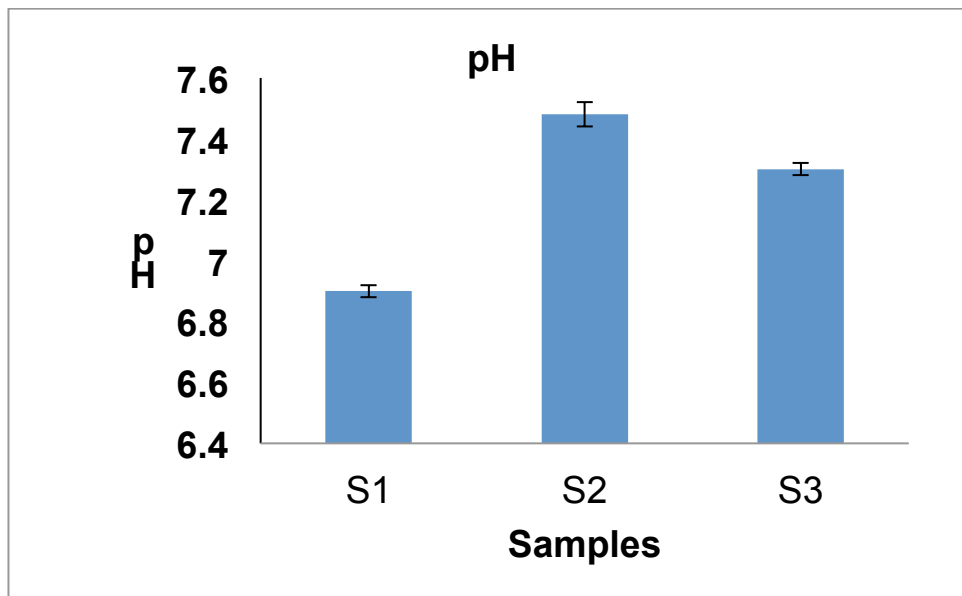


Figure 3: Graph showing pH variations of water samples from sampling sites.

- Hardness:** Hardness gives an idea about the presence of carbonate, bicarbonate and other ions in water sample. If there is a high amount of ions present in water, it is said to be hard water. Water is also classified according to the concentration of total hardness i.e., water possessing hardness of 75mg/l, 76-150mg/l, 151-300mg/l and more than 300mg/l is classified as soft, moderately soft, hard and very hard respectively (Saravanakumar and Kumar, 2011). Based on classification, water at **S1** and **S2** was found to be hard water and at **S3** was considered to be moderately soft. Hard water has no health effects on biota and is more palatable than soft water. Therefore, water samples from **S1** and **S2** are fit for use.

Krishnamet. *al.*, (2008) studies about the relationship that calcium cations cause hardness in water and enhance the development of zooplankton, phosphate and alkalinity of aquatic system.

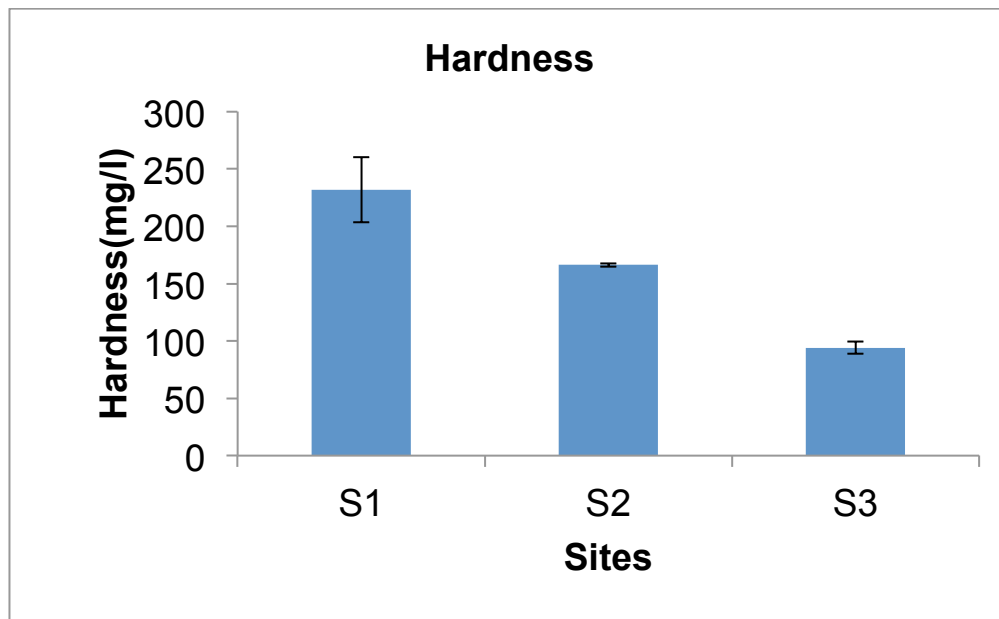


Figure 4: Showing the variation in hardness concentration from sampling sites.

3. **Alkalinity:** It is a measure of ability to neutralize the acids and its ability to maintain the relative constant pH. High alkalinity of aquatic system is due to presence of ions such as carbonate and hydroxide in the water (Jain, 2000). Bharadwaj and Sharma, 1999 reported that alkalinity is directly related with pH. All the water samples from sampling sites were not show any signs of alkalinity as indicated by pH values. They don't turn pink on addition of phenolphthalein indicator.
4. **Dissolved oxygen (DO):** DO give an idea that how much oxygen is dissolved in a unit volume of water. It measures the capability of water to support aquatic organisms. If there is depletion of dissolved oxygen in water sample this will indicate the presence of pollutants and hence pollution in that water sample (PremlataVikal, 2009). DO is often related with temperature, solubility, oxidation by microorganisms for *e.g.*, bacteria, photosynthesis by flora etc. At high temperature, oxygen-holding capacity of water declines (Welch, 1952). Low value of DO in water indicates the breakdown of organic matter occurs by anaerobic means. Presence of less organic waste and nutrients in the water samples results in high DO (Idowu and Ugwumba, 2013).

In this study, the value of DO at **S2** was under permissible range, but at **S1** and **S3** DO values were much higher than standards according to WHO and USEPA. This means that at **S1** and **S3** there is plenty of oxygen available for aquatic organisms and hence maintains the healthy conditions for them.

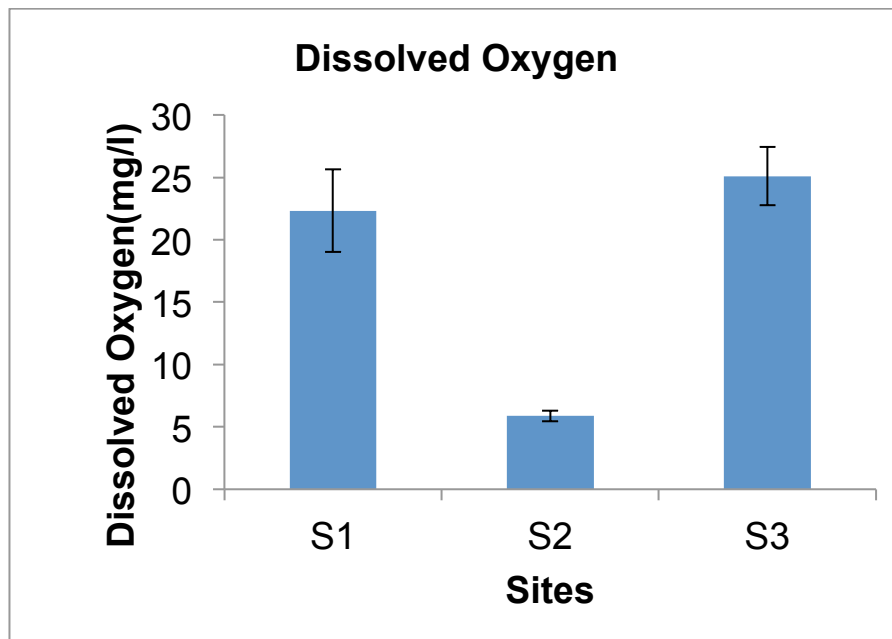


Figure 5: Showing the variation in DO from sampling sites.

- Biological Oxygen Demand:** It is a biochemical method which determines the amount of oxygen required by aerobic organisms in the water sample to disintegrate the organic matter at particular temperature i.e., 20 °C and the time taken for this experiment is generally five days. It is very essential test which tells about the biodegradability of any water sample. Singh and Raj, (1999) studied that if there were high values of BOD, this was a clear indication of organic contamination in water sample. BOD values at sites **S1**, **S2** and **S3** were 7.84, 9.55 and 7.86 respectively which is higher than the standard value given by WHO. This gives an idea that there is high contamination of organic matter at all sampling sites. As BOD was higher than permissible range, which means depletion of oxygen occurs rapidly due to more degradation of organic waste.

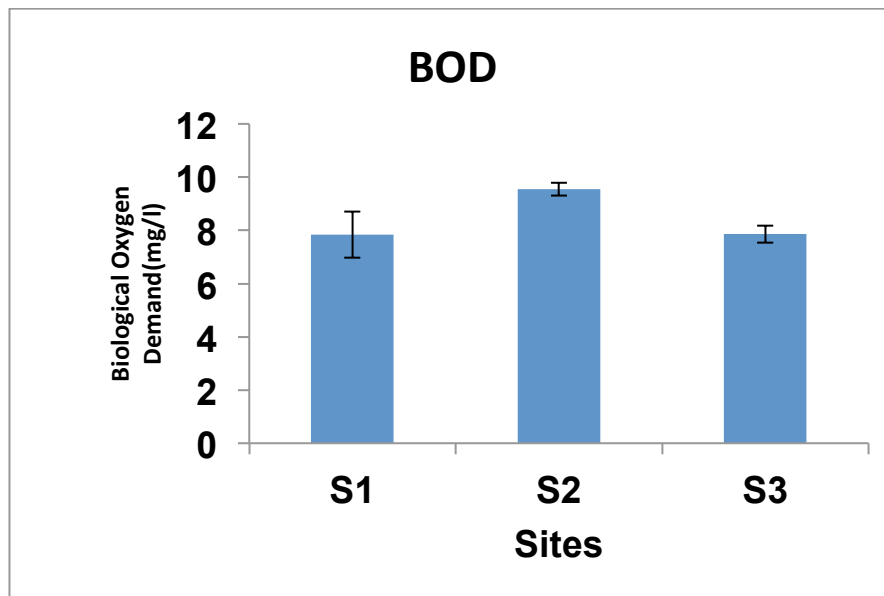


Figure 6: Showing the variations of BOD from sampling sites.

6. **Limnological analysis:** Limnological study also has its importance along with physico-chemical parameters to study the pollution status of water because planktons are considered as bioindicators of pollution. After qualitative analysis of planktons at S3 showed the presence of phytoplankton of Chlorophyceae, Euglenophyceae, Bacillariophyceae and Cyanophyceae families and zooplankton belongs to Crustacea, Rotifera and Protozoa groups. It was found that at S1 large number of species were found belongs to family Bacillariophyceae, Chlorophyceae, Euglenophyceae and Cyanophyceae among phytoplankton and zooplankton belongs to Protozoa, Crustacean, Rotifera and Insecta groups. Bacillariophyceae, Cyanophyceae and Chlorophyceae among phytoplankton, whereas Insecta, Crustacea and Rotifera among zooplankton were reported at S2.
7. **Trace elements:** Trace elements also form the chemical part of water bodies. They include major, minor and heavy metals. Analysis of water sample with atomic absorption spectroscopy showed the presence of large number of elements from all sampling sites. But the major concerned issue was presence of radioactive isotope i.e., Uranium (U238) in water samples from sites S1 and S2. According to WHO, the concentration of uranium in water should not exceed 0.02mg/l, otherwise it will be toxic to humans and animals.

Category	7Li (STD)	9Be (STD)	11B (STD)	23Na (KED)	24Mg (KED)	27Al (KED)	39K (KED)	44Ca (KED)	48Ti (KED)	51V (KED)
Concentration average	335.907 ppb	176.508 ppb	-254.193 ppb	13,188.021 ppb	23,067.322 ppb	9,260 ppb	10,102.478 ppb	8,623.210 ppb	201.898 ppb	0.607 ppb
Concentration per Run 1	241.831 ppb	-4.060 ppb	-339.492 ppb	12,837.990 ppb	21,711.872 ppb	4,143 ppb	9,197.417 ppb	7,194.979 ppb	170.000 ppb	0.476 ppb
Concentration per Run 2	509.604 ppb	372.234 ppb	-81.062 ppb	12,064.046 ppb	20,873.815 ppb	18,296 ppb	9,332.313 ppb	8,127.519 ppb	174.556 ppb	0.518 ppb
Concentration per Run 3	256.288 ppb	161.349 ppb	-342.024 ppb	14,662.028 ppb	26,616.291 ppb	5,341 ppb	11,777.703 ppb	10,547.132 ppb	261.138 ppb	0.827 ppb
Concentration RSD	44.8 %	106.9 %	59.0 %	10.1 %	13.4 %	84.8 %	14.4 %	20.1 %	25.4 %	31.6 %

Category	52Cr (KED)	55Mn (KED)	57Fe (KED)	59Co (KED)	60Ni (KED)	63Cu (KED)	66Zn (KED)	75As (KED)	75As (STD)	77Se (KED)
Concentration average	0.155 ppb	-0.011 ppb	8.235 ppb	0.066 ppb	0.940 ppb	1.937 ppb	-25.272 ppb	2.422 ppb	3.013 ppb	0.000 ppb
Concentration per Run 1	0.079 ppb	-0.086 ppb	8.173 ppb	0.050 ppb	0.643 ppb	1.780 ppb	-25.246 ppb	2.422 ppb	3.740 ppb	0.000 ppb
Concentration per Run 2	0.150 ppb	-0.026 ppb	5.387 ppb	0.070 ppb	1.174 ppb	1.930 ppb	-25.383 ppb	2.283 ppb	2.366 ppb	0.000 ppb
Concentration per Run 3	0.238 ppb	0.077 ppb	11.145 ppb	0.078 ppb	1.004 ppb	2.101 ppb	-25.188 ppb	2.562 ppb	2.934 ppb	0.000 ppb
Concentration RSD	51.3 %	720.7 %	35.0 %	22.0 %	28.8 %	8.3 %	0.4 %	5.8 %	22.9 %	

Category	85Rb (KED)	88Sr (KED)	93Nb (KED)	95Mo (KED)	107Ag (KED)	111Cd (KED)	115In (KED)	121Sb (KED)	133Cs (KED)	137Ba (KED)
Concentration average	3.613 ppb	320.134 ppb	1.211 ppb	2.219 ppb	0.224 ppb	0.109 ppb	0.103 ppb	3.683 ppb	19.368 ppb	334.197 ppb
Concentration per Run 1	3.233 ppb	311.471 ppb	1.174 ppb	2.477 ppb	0.274 ppb	0.158 ppb	0.063 ppb	4.518 ppb	12.467 ppb	213.574 ppb
Concentration per Run 2	3.620 ppb	315.429 ppb	1.266 ppb	2.095 ppb	0.185 ppb	0.074 ppb	0.098 ppb	4.986 ppb	45.520 ppb	461.018 ppb
Concentration per Run 3	3.987 ppb	333.501 ppb	1.192 ppb	2.085 ppb	0.214 ppb	0.095 ppb	0.149 ppb	1.545 ppb	0.117 ppb	328.000 ppb
Concentration RSD	10.4 %	3.7 %	4.0 %	10.1 %	20.2 %	40.3 %	42.0 %	50.7 %	121.2 %	37.1 %

Category	205Tl (KED)	208Pb (KED)	208Pb (STD)	209Bi (KED)	238U (KED)	238U (STD)
Concentration average	1.075 ppb	1.294 ppb	0.551 ppb	24.468 ppb	14.704 ppb	6.418 ppb
Concentration per Run 1	1.977 ppb	2.066 ppb	0.563 ppb	28.994 ppb	14.848 ppb	6.547 ppb
Concentration per Run 2	1.035 ppb	0.743 ppb	0.572 ppb	21.071 ppb	15.441 ppb	6.457 ppb
Concentration per Run 3	0.213 ppb	0.892 ppb	0.517 ppb	23.347 ppb	13.823 ppb	6.249 ppb
Concentration RSD	82.1 %	58.7 %	5.4 %	16.6 %	5.6 %	2.4 %

Table 4: Showing concentrations of trace elements from site S1

Category	7Li (STD)	9Be (STD)	11B (STD)	23Na (KED)	24Mg (KED)	27Al (KED)	39K (KED)	44Ca (KED)	48Ti (KED)	51V (KED)
Concentration average	21.717 ppb	-4.059 ppb	-315.448 ppb	25.928.452 ppb	20.539.343 ppb	9.135 ppb	7.075.935 ppb	2.610.251 ppb	60.425 ppb	0.893 ppb
Concentration per Run 1	21.748 ppb	-4.036 ppb	-198.556 ppb	22.787.186 ppb	17.157.399 ppb	8.186 ppb	5.397.572 ppb	2.023.749 ppb	44.556 ppb	0.601 ppb
Concentration per Run 2	21.173 ppb	-4.071 ppb	-373.204 ppb	26.660.832 ppb	20.985.821 ppb	18.220 ppb	7.558.268 ppb	2.801.485 ppb	69.210 ppb	0.960 ppb
Concentration per Run 3	22.231 ppb	-4.070 ppb	-374.585 ppb	28.337.339 ppb	23.474.808 ppb	0.998 ppb	8.271.964 ppb	3.005.520 ppb	67.407 ppb	1.119 ppb
Concentration RSD	2.4 %	0.5 %	32.1 %	11.0 %	15.5 %	94.7 %	21.2 %	19.8 %	22.6 %	29.7 %
Category	52Cr (KED)	55Mn (KED)	57Fe (KED)	59Co (KED)	60Ni (KED)	63Cu (KED)	66Zn (KED)	75As (KED)	75As (STD)	77Se (KED)
Concentration average	0.137 ppb	-0.055 ppb	2.601 ppb	0.019 ppb	0.613 ppb	1.176 ppb	-18.066 ppb	3.936 ppb	3.239 ppb	0.000 ppb
Concentration per Run 1	0.079 ppb	-0.009 ppb	3.158 ppb	0.013 ppb	0.513 ppb	1.081 ppb	-18.646 ppb	4.168 ppb	3.521 ppb	0.000 ppb
Concentration per Run 2	0.166 ppb	-0.069 ppb	0.557 ppb	0.022 ppb	0.563 ppb	0.945 ppb	-22.102 ppb	2.283 ppb	3.406 ppb	0.000 ppb
Concentration per Run 3	0.166 ppb	-0.096 ppb	4.087 ppb	0.022 ppb	0.763 ppb	1.502 ppb	-13.451 ppb	5.357 ppb	2.791 ppb	0.000 ppb
Concentration RSD	37.0 %	74.6 %	70.3 %	26.0 %	21.6 %	24.7 %	24.1 %	39.4 %	12.1 %	
Category	85Rb (KED)	88Sr (KED)	93Nb (KED)	95Mo (KED)	107Ag (KED)	111Cd (KED)	115In (KED)	121Sb (KED)	133Cs (KED)	137Ba (KED)
Concentration average	1.810 ppb	663.637 ppb	0.947 ppb	4.574 ppb	0.263 ppb	0.120 ppb	0.441 ppb	4.216 ppb	0.722 ppb	562.597 ppb
Concentration per Run 1	2.198 ppb	656.668 ppb	1.001 ppb	4.368 ppb	0.230 ppb	0.116 ppb	0.219 ppb	0.399 ppb	0.106 ppb	556.551 ppb
Concentration per Run 2	0.991 ppb	365.944 ppb	0.420 ppb	2.181 ppb	0.121 ppb	0.084 ppb	0.989 ppb	11.801 ppb	2.003 ppb	563.947 ppb
Concentration per Run 3	2.241 ppb	968.299 ppb	1.420 ppb	7.175 ppb	0.439 ppb	0.158 ppb	0.116 ppb	0.449 ppb	0.056 ppb	567.295 ppb
Concentration RSD	39.2 %	45.4 %	53.1 %	54.7 %	61.5 %	31.0 %	108.1 %	155.8 %	153.8 %	1.0 %
Category	205Tl (KED)	208Pb (KED)	208Pb (STD)	209Bi (KED)	238U (KED)	238U (STD)				
Concentration average	0.029 ppb	0.377 ppb	0.189 ppb	8.855 ppb	38.941 ppb	16.535 ppb				
Concentration per Run 1	0.035 ppb	0.376 ppb	0.189 ppb	9.301 ppb	38.663 ppb	16.536 ppb				
Concentration per Run 2	0.022 ppb	0.383 ppb	0.188 ppb	8.968 ppb	38.571 ppb	16.787 ppb				
Concentration per Run 3	0.030 ppb	0.370 ppb	0.189 ppb	8.416 ppb	39.589 ppb	16.283 ppb				
Concentration RSD	21.3 %	1.8 %	0.3 %	5.0 %	4.4 %	1.5 %				

Table 5: Table showing concentrations of trace elements from site S2.

Category	7Li (STD)	9Be (STD)	11B (STD)	23Na (KED)	24Mg (KED)	27Al (KED)	39K (KED)	44Ca (KED)	48Ti (KED)	51V (KED)	52Cr (KED)
Concentration average	-0.024 ppb	-4.073 ppb	-413.373 ppb	-92.938 ppb	-8.362 ppb	-1.248 ppb	-82.988 ppb	-6.470 ppb	-0.061 ppb	-0.008 ppb	-0.004 ppb
Concentration per Run 1	-0.024 ppb	-4.073 ppb	-413.373 ppb	-92.938 ppb	-8.362 ppb	-1.248 ppb	-82.988 ppb	-6.470 ppb	-0.061 ppb	-0.008 ppb	-0.004 ppb
Concentration per Run 2	-0.024 ppb	-4.073 ppb	-413.373 ppb	-92.938 ppb	-8.362 ppb	-1.248 ppb	-82.988 ppb	-6.470 ppb	-0.061 ppb	-0.008 ppb	-0.004 ppb
Concentration per Run 3	-0.024 ppb	-4.073 ppb	-413.373 ppb	-92.938 ppb	-8.362 ppb	-1.248 ppb	-82.988 ppb	-6.470 ppb	-0.061 ppb	-0.008 ppb	-0.004 ppb
Concentration RSD	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %

Category	55Mn (KED)	57Fe (KED)	59Co (KED)	60Ni (KED)	63Cu (KED)	66Zn (KED)	75As (KED)	75As (STD)	77Se (KED)	85Rb (KED)	88Sr (KED)
Concentration average	-0.172 ppb	-0.743 ppb	-0.001 ppb	-0.047 ppb	-0.121 ppb	-31.378 ppb	-0.093 ppb	-0.039 ppb	0.000 ppb	0.000 ppb	-0.448 ppb
Concentration per Run 1	-0.172 ppb	-0.743 ppb	-0.001 ppb	-0.047 ppb	-0.121 ppb	-31.378 ppb	-0.093 ppb	-0.039 ppb	0.000 ppb	0.000 ppb	-0.448 ppb
Concentration per Run 2	-0.172 ppb	-0.743 ppb	-0.001 ppb	-0.047 ppb	-0.121 ppb	-31.378 ppb	-0.093 ppb	-0.039 ppb	0.000 ppb	0.000 ppb	-0.448 ppb
Concentration per Run 3	-0.172 ppb	-0.743 ppb	-0.001 ppb	-0.047 ppb	-0.121 ppb	-31.378 ppb	-0.093 ppb	-0.039 ppb	0.000 ppb	0.000 ppb	-0.448 ppb
Concentration RSD	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.9 %	0.0 %	0.0 %	0.0 %

Category	93Nb (KED)	95Mo (KED)	107Ag (KED)	111Cd (KED)	115In (KED)	121Sb (KED)	133Cs (KED)	137Ba (KED)	205Tl (KED)	208Pb (KED)	208Pb (STD)
Concentration average	0.000 ppb	-0.016 ppb	-0.004 ppb	0.000 ppb	0.000 ppb	-0.004 ppb	0.000 ppb	-0.043 ppb	0.000 ppb	-0.027 ppb	-0.024 ppb
Concentration per Run 1	0.000 ppb	-0.016 ppb	-0.004 ppb	0.000 ppb	0.000 ppb	-0.004 ppb	0.000 ppb	-0.043 ppb	0.000 ppb	-0.027 ppb	-0.024 ppb
Concentration per Run 2	0.000 ppb	-0.016 ppb	-0.004 ppb	0.000 ppb	0.000 ppb	-0.004 ppb	0.000 ppb	-0.043 ppb	0.000 ppb	-0.027 ppb	-0.024 ppb
Concentration per Run 3	0.000 ppb	-0.016 ppb	-0.004 ppb	0.000 ppb	0.000 ppb	-0.004 ppb	0.000 ppb	-0.043 ppb	0.000 ppb	-0.027 ppb	-0.024 ppb
Concentration RSD	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %

Category	209Bi (KED)	238U (KED)	238U (STD)
Concentration average	-0.003 ppb	-0.006 ppb	-0.005 ppb
Concentration per Run 1	-0.003 ppb	-0.006 ppb	-0.005 ppb
Concentration per Run 2	-0.003 ppb	-0.006 ppb	-0.005 ppb
Concentration per Run 3	-0.003 ppb	-0.006 ppb	-0.005 ppb
Concentration RSD	0.0 %	0.0 %	0.0 %

Table6: Showing concentrations of trace elements from site S3.

CONCLUSION AND FUTURE SCOPE

Analysis of physico-chemical and limnological studies from sampling sites leads to a conclusion that all the parameters from all stations were within permissible limits according to WHO, ICMR, ISI, PCPB and USEPA except BOD which was higher than the recommended values. But analysis of trace elements shows the presence of radioactive isotope i.e., U238 from **S1** and **S2**. The presence of this element is of great concern because it is very detrimental for the organisms which are using the wwater from the site **S1** and **S2**. Government must take steps so that untreated water should not be drained into water bodies. The water sample from site **S3** was suitable for use.

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