ECOLOGY AND ECONOMIC EVALUATION OF DAL LAKE IN SRINAGAR, KASHMIR

Thesis Submitted for the Award of the Degree of

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in

Botany

By

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Dedicated

to

Beloved Mother and Father

Declaration

I, hereby declared that the presented work in the thesis entitled **“Ecology and economic evaluation of Dal Lake in Srinagar, Kashmir**” in fulfilment of degree of **Doctor of Philosophy (Ph. D.)** is outcome of research work carried out by me under the supervision of **Dr. Bhupendra Koul**, working as **Associate Professor**, in the **Department of Botany**, **School of Bio Engineering and 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 another investigator. 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 "**Ecology and economic evaluation of Dal Lake in Srinagar, Kashmir"** submitted in fulfillment of the requirement for the award of degree of **Doctor of Philosophy (Ph.D.)** in the **Department of Botany**, **School of Bio Engineering and Biosciences**, is a research work carried out by **Siraj Yousuf,** (Registration No.**41800881**), is bonafide record of his/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.

(Signature of Supervisor)
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Abstract

Planet earth, the self-sustaining system of the universe, acts as an ecological unit wherein different components of the biosphere interact with each other through the evolutionary process and are interdependent upon each other (Zuber, 2007; Saulnier-Talbot, 2016). Wetlands are the aquatic ecosystems which play very important role in the purification process of water, act as sinks of carbon dioxide and help in the reduction of climate change and stabilization of microclimate of the area. They also help in upliftment of the economy of local people and act as attraction sites for tourists.

The Kashmir Himalaya has been endowed with an outstanding landscape, and a large number of wetlands scattered across the valley. The Dal Lake which is the focal point of Kashmir's glory in the centre of the city is surrounded by the Mughal gardens, mesmerizing foreshore road and the Dargah shrine on one of its banks adds to the beauty of this lake. Freshwater wetlands are significant and distinctive aspects of the world's landscape and their water quality control involves testing their soluble and insoluble elements (Hussian et al., 2004; Mills et al., 2017). However, eutrophication has been the most serious problem faced by these water bodies, especially in densely populated areas. Increased nutrient loading has caused turbid water, cyanobacterial blooms, and biodiversity loss in many wetlands around the world (Cooke and Welch, 1993; Boardman, 2013). The ecosystem of Dal Lake is vital to both the environment and human populations, but human activity is putting it in danger, and the loss of this body of water and its associated benefits is a real possibility (Khan and Shah, 2004; Sheik et al., 2014).

Ecological conservation is a strategy to maintain, protect, and restore these habitats. Physical and biochemical functions that are essential to the preservation of safe environmental conditions in water bodies are strategically facilitated (Mitsch and Gosselink, 2000; Taloor et al., 2020). With this in mind, the current study was conducted on Dal Lake regarding (i) evaluation of the impact of anthropogenic activities on the ecology of Dal Lake, (ii) identification and classification of different macrophytes growing

in the Dal Lake, (iii) evaluation of the physico chemical properties of water in Dal Lake and (iv) economic evaluation of the Dal Lake.

For the evaluation of impact of anthropogenic activity in the catchment area of the Dal Lake a survey (80 individuals) was conducted in the vicinity of Dal Lake in year 2021 to find out the factors which are actually ailing the ecology and biotic status of the water body. A Likert scale was used for the survey purpose wherein a host of questions (Questionere attached) were asked to the participants to get the first-hand information about the pollution of the lake. Our findings with respect to the objective 1 were: (i) reckless use of fertilizers and pesticides within the vegetable gardens of the Dal Lake was estimated in terms of Kanals of land being converted into floating gardens by the inhabitants living with in the Dal Lake (Rather et al., 2020; Saleem, 2016) and the results were recorded, (ii) the increasing population in the catchment area of Dal Lake contributes to the increasing inputs of nitrogen, phosphorus and heavy metal load, (iii) during the study period, approximately 1963.50 kilograms of fertilizers (Urea, DAP, MOP and 178.50 Kgs of pesticides were used in one season which contributed to the eutrophication problem.

For identification and classification of macrophytes growing in the Dal Lake, the study site was divided into four sampling sites namely (A) Hazratbal, (B) Habbak, (C) Laam and (D) Brarinambal. The dominant macrophyte plant species were collected and identified at Kashmir University herbarium, and the herbarium of these species was prepared. Random Quadrant method was used for determining different community characteristics (Misra, 1968; Shanon-Weiner, 1949). Our findings were: (i) Nineteen macrophytes species (*Azolla* sp., *Ceratophyllum demersum* L. *Hydrocharis dubia* L., *Myriophyllum spicatum* L., *Nelumbo nucifera* L., *Nymphaea alba* L., *Nymphoides peltata* L., *Potamogeton crispus* L., *Trapa natans* L., *Potamogeton lucens*, *Salvinia natans*, *Typha angustata*, *Phragmites australis*, *Lemna minor*, *Sagitaria latifolia*, *Cyperus* sp., *Carex* sp., *Polygonum amphibium*, *Nasturtium officinale*) were found at the four sites of the Dal Lake and were classified into different groups such as 'emergent~~s~~', 'submerged', 'rooted floating type' and 'free floating', (ii) The diversity indices, values such as 'Shanon index' and 'Simpson's index' was calculated and the highest value of Shanon index was reported at the Hazratbal site which was 1.25 and lowest at the Laam site which was 0.71. Likewise, the highest and lowest values of Simpson's index was reported at the Hazratbal and Laam site of Dal Lake which was 0.65 and 0.37 respectively, (iii) The Importance Value Index (IVI) of the species was also calculated and it was found the the values of IVI were highest in case of *Azolla* species which forms a complete mat on the water surface.

The change in water characteristics as a result of anthropogenic activities was calculated by physico chemical analysis of water following the APHA guidelines, in the different seasons of the year 2020 and 2021, at four different sites (A) Hazratbal, (B) Habbak, (C) Laam and (D) Brarinambal, during the period of study. The important parameters such as dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates and phosphates were estimated in order to find out the impact of pollution in Dal Lake. Our findings were: (i) The lowest DO content was recorded at the Hazratbal site (4.84 ± 0.35 mg/l) and the highest at the Laam site (6.50 ± 0.26 mg/l) of the lake. Likewise, highest and lowest BOD values were 31.13 ± 0.93 mg/l at Hazratbal and 24.40 ± 0.26 mg/l at the Habbak site (ii) The nitrate and phosphate concentrations which are the primary cause of eutrophication also showed peak at the different sites and the higher values were observed at the Hazratbal site (0.86 mg/l) and lowest at the Laam site (0.42 mg/l), indicating their higher nutrient status, (iii) The heavy metal (HM) estimation was done using ICP-MS technique, and out of the five HMs (molybdenum, chromium, arsenic, cadmium and lead) assessed during the present study, chromium could not be detected from the collected samples at any of the sites within the lake. The highest values of lead were recorded at the Hazratbal site (6.828 ± 0.003 ppb) and lowest at the Habbak site (2.492 ± 0.002 ppb) and for molybdenum, highest values were recorded at the Brarinambal site (4.787 ± 0.002 ppb) and lowest at the Habbak site (1.703 ± 0.003 ppb) respectively. The decreasing order of HMs at the four sites were lead (6.828 ± 0.003 ppb) > molybdenum (4.787 ± 0.002 ppb) > arsenic (2.711 ± 0.029 ppb) > cadmium (0.989 ± 0.002 ppb).

For economic valuation, direct valuation strategies like the production function, and indirect valuation approaches such as the cost of illness approach, contingent valuation, and hedonic pricing, were used in the current study. A survey of 296 was conducted to find the response with regard to the services provided by the Dal Lake. Economic valuation involves putting a price on the commodities and services that environmental resources deliver, regardless of whether or not market pricing is available (Barbier et al., 1997; Lanzanova and Reynaud, 2017). Our findings were: (a) The economic activities undertaken within the Dal Lake by way of hanji activity (worker activity) and water extraction contribute to Rs 16, 18, 66, 000 crores per year, (b) The prevalence of water-borne infections among the people who drink lake water reflects the overall health of the water body. The cost incurred on medicines and treatment during the study period was found to be rupees 39,45,000, (c) People were willing to pay high price for the property near the lake, and the difference in property prices near and far from the lake was around 14.2 percent per square feet. The existence value of the Dal Lake and the stabilization of microclimate by the lake does not come under valuation process (Darby et al., 2021).

Thus, the aforementioned study was undertaken to find the possible cause of deteriorating water quality and related health hazards, increase in the dominance and abundance of macrophytes, and suggesting some for improving the water quality, basin stabilization, and preventing excess use of fertilizers within the floating gardens, besides making judicious use of resources obtained from Dal Lake, and Govt. intervention (strict action against violation of green zone regulations; entry-fee at the entrance of the lake to decrease the foot-fall etc.), for developing the road-map for effective management of the water body, by involving the academicians and technocrats.

Preface

Wetlands play a very important role in maintaining the ecological balance by acting as pollutant sinks. Besides providing habitat to the variety of aquatic and terrestrial life, they are important in maintaining biodiversity and act as recreational hotspots. Due to extensive anthropogenic pressure these biotypes are deteriorating due to improper management. Extensive urban and rural development will further deteriorate the carrying capacity of this eutrophic water body.

Wetlands act as transitional zones and their socio-economic importance is felt at an increasing rate. They are the source of water, food, fodder, fisheries and act as important ecotourism sites besides stabilizing the microclimate of the particular area. Due to unsustainable utilization of the wetland resources, they are under serious threat and immediate efforts need to be undertaken for their conservation and restoration process before the water body reaches to its climactic succession. The Dal Lake located in the heart of Srinagar has hundreds of houseboats and shikaras which cater to the needs of tourists during all seasons of the year. It also has several floating gardens where vegetable cultivation is undertaken and supplied to the whole city thereby contributing to the economy of the state. However, due to reckless use of fertilizers and pesticides, the water body is under immense threat. It is in this backdrop, that the present study "Ecology and economic evaluation of the Dal Lake in Srinagar, Kashmir" was undertaken to find out the anthropogenic stress, physico-chemical parameters of water, estimation of dominant macrophytes and economic valuation of the water body, and the eco-restoration measures to be taken for sustainability of Dal Lake.

The present thesis entitled **"Ecology and Economic Evaluation of Dal Lake in Srinagar, Kashmir"** encompasses the details of the studies undertaken and analyses of results obtained under 9 major chapters as described below:

Chapter 1 - Introduction: This chapter includes a brief introduction of the increasing problem of water pollution and abundant macrophyte growth, besides the economic evaluation of the Dal Lake through TCM and CVM methods, and the necessary measures for the management of the waterbody.

Chapter 2 - Review of Literature: This chapter summarizes the different works undertaken on the wetland ecosystems, the review on the anthropogenic activities and their impact on the Dal Lake, macrophytes distribution, physico-chemical features of water and economic evaluation of the lake.

Chapter 3 - Hypothesis: This chapter describes the hypothesis of the present work.

Chapter 4 - Aims and Objectives: This chapter describes the aims and objectives of the present study.

Chapter 5 - Methodology: This chapter includes the surveys, methodology for calculation of diversity indices, protocols for physicochemical parameters and the valuation techniques for economic evaluation of the Dal Lake.

Chapter 6.1-6.5. - Results and Discussion: This chapter includes the results and discussion related to the studies on Impact of increasing population and the use of fertilizers and pesticides on the Dal Lake, survey characteristics of anthropogenic activity in the vicinity of Dal Lake, identification and classification of macrophytes growing in the Dal Lake, physico-chemical Parameters of Dal Lake and economic evaluation of the Dal Lake.

Chapter 8 - Summary and Conclusions: The study that has been presented in this thesis and the findings that have been reached are summarized in this chapter.

Chapter 9 - Bibiliography: This chapter contains citations of references used in the present investigation.

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Abbreviations

APHA	American public health agency
BIS	Bureau of Indian standards
BOD	Biological oxygen demand
BHC	Benzene hexa chloride
CATINCOM	Category of income
COD	Chemical oxygen demand
CVM	Contingent valuation method
Do	Dissolved oxygen
DAP	Diammonium phosphate
EDTA	Ethylenediamine tetraacetic acid
GIS	Geographical information system
HMs	Heavy metals
IVI	Importance value index
LAWDA	Lakes and waterways development authority
LSD	Least significant difference
LULC	Land use land cover
MRA	Meta regression analysis
NEERI	National environmental engineering institute
NFBM	Number of family members below 18
NFMA	Number of adult family members
OCC	Occupation
PED	Pollution and environmental degredation
PHE	Public health engineering
SD	Standard deviation
TEW	Total environmental worth
TDS	Total dissolved solids
VOLDON	Voluntary donation
WHO	World health organization

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CHAPTER 1

Introduction

Introduction

The lakes are closed water bodies that are completely enclosed by land and have no direct connection to the ocean (Lehner, 2004). Planet earth is the self-sustaining system of the universe, wherein the different species interact with each other and their evolutionary success depends on their levels of competitiveness (Moss, 1998). As the resources for growth are scarce the ecological competitions are common, as a result of this organisms have evolved eating and being eaten mechanisms, which has helped them to use these resources efficiently, giving the appearance of a homeostatic ecosystem (Zuber, 2007). Fresh water bodies like rivers, lakes and ponds that have served as luxurious reservoirs of water, are recognizable structures with physical and chemical properties that subsequently changes with weather patterns, climate, chemicals and organic wastes (Welch and Cooke, 2005; Leavitt et al., 2009).

All aquatic ecosystems like lakes, go through a full life cycle, and with the exception of a few small lakes, the natural process of development to destruction is a very slow event (Goldman and Horne, 1983; Barr et al., 2013). Contrary to popular belief, human interventions such as sewage disposal and agricultural runoff (pesticides, weedicides, fertilizers), as well as encroachment, have resulted in a new type of eutrophication known as 'cultural eutrophication' which has proven to be the most potent tool, resulting in their ageing (Wetzel, 1985; Zuber, 2007; Khan et al., 2014; Parray et al., 2020). Increased anthropogenic activity on lake water systems result in significant pollution, such as phosphorus, nitrates and heavy metal load which promote rapid water quality degradation (Nuzhat et al., 2002; Irfana et al., 2018). Surprisingly, sewage treatment plants break down the particulate matter and dump the majority of the nutrient load into the waters as a result of this accelerated discharge of sewage and fertilizers involuntary senescence has occurred (Saleem and Jeelani, 2017).

The lotic and lentic ecosystems are constantly under threat from a variety of sources, making conservation of these resources increasingly important. With this in mind, the Ramsar Convention of 1971 was signed by many countries of the world to outline the potential services provided by wetlands, which include water supply, food, nutrition, medicine, waste purification, and buffering against adverse climatic conditions (Ansari, 2012). Rapid population growth, economic boom, and expanding agricultural, industrial, and urban development have all had a very significant effect on the wetland resources, resulting in a significant accumulation of toxic organic compounds that have degraded most wetland ecosystems worldwide, including those in India (Chau and Sin, 1992; Boardman, 2013).There has been a decline in the water quality of lakes due to sedimentation and overutilization (Sheikh et al., 2014; Parray et al., 2021), which has impacted the entire structural development of the ecosystem (Qadri and Yousuf, 2008; Zhu and Feng, 2008). Dal Lake water which was once used for drinking purposes, has quickly deteriorated in quality in the recent decades, owing to anthropogenic inputs such as sewage from houseboats, hotels, and the surrounding population (Trisal,1987; Saleem and Jeelani, 2017).The unregulated use of pesticides within and around the catchment of wetlands has been found to cause various diseases and their gradual degradation within the environment causes irreversible harm to various aquatic biota (Parray et al., 2020).

The Kashmir Himalaya has been endowed with an enormous landscape, with a large number of wetlands spread across the valley. Dal Lake which is surrounded by majesty mountain peaks and the world-famous Mughal gardens such as Shalimar and Nishat baag on its banks, and revered Hazratbal shrine on the other bank adds to its mesmerizing beauty. These lake ecosystems are of paramount importance to the environment and human population, but due to the looming threat they may be lost before natural succession process (Khan and Shah, 2004; Rather et al., 2007; Sheik et al., 2014). Eutrophication has been a very serious problem faced by the administrators from decades, especially in densely populated communities. Increased nutrient loading has caused turbid water and biodiversity loss in many wetlands all over the world (Cooke and Welch, 1993; Heena et al., 2017; Boardman, 2013; Khanday et al., 2018). Phosphorus loading from within the lake sediments has been found to be the key factor in slowing down lake and wetland recovery process and management (Marsden 1989; Jensen and Jeppesen, 2005; Mushtaq et al., 2013). Assessing the soluble and insoluble constituents is an important means of maintaining their water quality (Hussian et al, 2004; Shariqa Maryam, 2017; Mills et al., 2017). Physical and biological functions that are necessary for maintaining healthy environmental conditions in water bodies are constantly being assessed (Mitsch and Gosselink, 2000; Taloor et al., 2020). Despite the fact that several researchers have studied the Kashmir Himalayan wetlands (Khan and Shah, 2004), nutrient dynamics (Parray et al 2021), Carbon sequestration (Lolu et al., 2019), distribution pattern of macrophytes (Dar et al., 2014) and phytosociology (Ara et al., 2004), however more concrete studies need to be under taken to reach the final goal.

These natural resources are seen as common property resources in economic terms, collectively owned by society as a whole or none. While trying to find out how to protect such resources, conservation biologists all around the world have recently adopted an economic based technique for their biodiversity preservation. Although there are scientific and educational methods of adding a value to a resource, the primary motivation for adopting such a conservation methodology is that government and the corporate machinary currently use economic valuation as a primary tool for this process. When the loss of biological diversity is expected to involve monetory loss, then the governments and corporations must take appropriate measures to prevent it (Emerton, 2016).

Economic valuation involves putting a price on the services that environmental resources deliver, regardless of whether or not market pricing is available. The economic value of a particular thing or service is usually determined by how much we are prepared to pay for, minus how much it costs to produce it (Barbier et al., 1997; Lanzanova and Reynaud, 2017). People, companies, and governments, surprisingly, utilize and deplete these resources for little or no cost. A market failure and a condition known as the tragedy of the commons occurs, in which the resource is destroyed for one and all (Hardin, 1968, 1985). When resources are misallocated and only few individuals benefit at the cost of rest of the society, a market failure occurs (Hong Fonf et al., 2017). The loss of wetlands has a huge environmental impact and it is important that the rest of the water bodies that are healthy need to be protected and conserved for their role in providing the vital services (Postel and Richter, 2003). Dhal (1999) and Woodward and Wui (2001), believed that Wetland conservation has been a topic of concern to the scientists because of their vital role in society and the environmental conservation (Spieles, 2005 and Chen et al., 2009). Damaged wetlands may not only lose their capacity to perform essential services, but they may also harm other interrelated ecosystems, making wetlands loss environmentally detrimental (Mitsch and Gosselink, 2000). Restoration economy refers to the utilization of greater quantity of money in the restoration process of water bodies (Cunningham, 2002 and Shah et al., 2016). To maintain and protect this important wealth, the Government of India (GOI) devised various initiatives, programs, and regulations for their posterity (Jyoti and Hemant, 2003). However, in the Kashmir Himalayan scene, such initiatives are nonexistent.

The current study focuses on a related topic of natural resource conservation in Dal Lake in the union territory of Jammu and Kashmir. The study is a thorough inquiry of the ecological status of this wetland, with the goal of assigning an economic value to it in order to ensure its long-term management and maintenance. Considering the underlying cause of environmental degradation being mostly gainful in origin, it is essential that the solution also includes economic principles. The assessment of the lake's biological health, followed by the economic relevance of this rich wetland, is the central focus of the current study on Dal Lake.

On account of the aforementioned considerations, the research was undertaken with the following objectives: (1) Evaluation of the impact of anthropogenic activities on the ecology of Dal Lake, (2) Identification and classification of different macrophytes growing in the Dal Lake, (3) Evaluation of the physico-chemical properties of water in Dal Lake and (4) Economic evaluation of the Dal Lake.

CHAPTER 2

Review of literature

2.1 Impact of anthropogenic activities on the ecology of Dal Lake

Appropriate research papers and administrative reports related to the theme of the present study from different search engines were selected. Peer reviewed articles and official literature were selected to ensure the quality of literature review. Our study was restricted to english language only and there was no formal restriction to the date of publication. Lake ecosystems are vital to the environment and biosphere, yet they are under increasing threat from man made influences and the changing environment. The time and beginning of human activities, as well as how they have impacted the aquatic water bodies in the past, are a cause of worry (Dearing et al., 2003; Kopf et al., 2015 and Saulnier-Talbot, 2016). Long-term environmental statistics are very useful for establishing the range of natural variability from which impact of anthropogenic disturbances can be calculated. The identity of this alternate permits the establishment of control goals (Gell et al., 2013). The consequences of human impact on water ecosystems can take many shapes and are spatially and temporarily variable. Detecting human influence is a challenging task due to complex and variable nature of human impacts (Mills et al., 2017).

Erosion is a global phenomenon controlled universally through geological phenomens (Peizhen et al., 2001). Increased soil erosion influences freshwater ecosystems by bringing about large doses of sediment and nutrients thereby resulting in enhanced turbidity and flooding (Boardman, 2013). Basin morphometry features and geology play a very important role in the recording of environmental perturbations which are related to erosion of soil. Factors including catchment area ratio (Dearing and Jones, 2003), depth of lake (Chiverrell, 2006; Milan et al., 2015) geology and high erosion capacity of the catchment also play a role (Koinig et al., 2003). Some of the studies indicated that agricultural activity playing a role in the erosion process.

Human actions which change the direction of water flow in the system is referred to as habitat change or habitat modification. This involves river engineering, groundwater modification, and water management. Damming can be used to create new aquatic structures, which might be considered as a habitat change. The creation of reserviors increases the level of water and enhances the provision of deeper and pelagic habitat types (Reeves et al., 2016).

Freshwater bodies (lakes) are developed by man from ancient times to store downpour water in India (Arya et al., 2011; Gagan, 2014). The water bodies are frequently utilized for different sorts of anthropogenic, religious exercises like mass bathing, inundation of idols which significantly influence the quality of the lake (Yadav et al., 2013; Nagar et al., 2016). These lakes are found close to the area of worship and are being utilized for washing and performing different religious activities (Chaturvedi and Kumar, 2011). The anthropogenic activities on lakes eventually, deteriorate the water quality and increase the number of poisonous compounds and shrinkage of catchment area. The physico-chemical factors have a significant importance in deciding the health of the water body besides its appropriateness for drinking, washing and fishing (Sharma et al., 2009).

Lake water assets are critical to the very existence of humans, economic upliftment and are the primary means of satisfying the need for drinking and industrial practices (Meybeck 1995; Saleem et al., 2015). There is an excess of 1,10,000 lakes bigger than 1 km^2 covering an area of about 2.30×106 km^2 (Meybeck, 1995; Wetzel, 2001). Lake biological system contains solutes from both natural and man-made sources (Jeelani and Shah, 2006; Saleem et al., 2015). Transportation of these solutes relies upon topography, environment and land use exercises around the lake (Jeelani et al., 2011; Sheik et al., 2014). The physico-chemical parameters of water which are influenced by human activities include different parameters such as pH, conductivity, and other abiotic parameters (dissolved oxygen, nitrate and phosphorous). Some of these factors if found outside the range set up by the certifying authorities may pose risk to the lives of people (BIS, 1999; WHO, 2006). Data and contextual analysis undertaken world over shows that the lakes and other water bodies are in danger from human activities such as overexploitation, and sedimentation process (Sheik et al. 2014; Saleem et al. 2015). Mitigating the lake and reservoir contaminations are necessary since accessibility of good quality water is a fundamental component of health and quality of life (Jeelani et al., 2014).

Dal Lake, a fresh water body in the centre of Srinagar city is an attraction for tourists thereby adding to the economic condition of the state. The presence of world- famous lotus in the Dal Lake and the eye-catching houseboats which provide shelter to the tourists enhance the economy of the union territory (Jeelani and Shah, 2006). However, because of the reckless use of fertilizers in the nearby agriculture fields and surface runoff the the problem of eutrophication is increasing day by day, therefore necessary steps need to be taken to conserve this threatned lake.

Fig.1. Anthropogenic pressure and the floating market in the Dal Lake.

Lakes are affected by a variety of causes that change their entire abiotic structure. Higher quantities of surface runnoff tends to bring about reduction in transparency of water. Fig. 1 shows the biotic pressure and the cultivation of vegetables in the floating gardens of Dal Lake.

The Dal Lake which has huge economic importance and the primary fascination for travelers in Kashmir, the anthropogenic elements (phosphorus and nitrogen) have significantly diminished its water quality index during the previous twenty years due to the illegal constructions near lake (Jeelani and Shah, 2006; Qadri and Yousuf, 2008; Khan et al., 2012; Saleem et al., 2015). Extensive work has been done on this lake (Trisal 1987; Kundangar et al., 2003; Jeelani and Shah, 2006; Singh et al., 2008), to find out the possible reasons of dwindling diversity within the Dal Lake. In order to acess the impact of anthropogenic activities a questionnaire was developed based on likert scale to arrive at a conclusion.

Ahearn et al. (2005), assessed the effect of catchment dynamics and the water quality parameters like DO, nitrates, phosphates and TDS. It was observed that agricultural activities around the lake are an essential factor indicating the pesticide and nitrogen load in the wetlands (Johnson et al., 1997). In addition to the quality of water, LULC changes have an enormous role in understanding the ramifications of environmental change and spillover potential (Beighley et al., 2008). Because of colossal anthropogenic factors and changing socio-economic conditions around there, the ecology of the Dal Lake has been influenced very badly. The untreated sewage dumped into the lake from various point and nonpoint sources has completely ruined the water chemistry of the Dal Lake. Furthermore, deforestation and agri-horticulture activities in the Dal Lake basin have resulted in substantial silt and higher quantities of nutrients into the lake, hastening its eutrophication process (Badar and Romshoo, 2007). Due to increase in the percent impervious area of the lake catchment, the rate of erosion increases after a brief period of precipitation, drawing more silt into the lake (Pandit and Qadri, 1990). Water contamination and the subsequent degredation of the Dal Lake environment are right now the important priorities of the country to adress. Environmental organizations are raising alarms to assign this lake as a “Ramsar site” with the goal that the protection of Dal Lake is taken care and funded globally.

Drinking water is the most fragile component of the ecosystem, and it is critical for the survival of all living forms on the planet (Arya et al., 2011). Aquatic ecosystems are frequently used for a variety of anthropogenic, religious activities like mass bathing and idol inundation, all of which have a negative influence on the water quality of the lake in question (Nagar et al., 2016; Yadav et al., 2013). These lakes are present in close proximity to the region of temples and are used for various activities such as cloth washing and doing other relegious exercises (Chaturvedi and Kumar, 2011). Anderson et al. (1976), developed an orderly categorization system consisting of three degrees of classification (I-III), each of which corresponds to a different level of information needed within a particular range. Urban areas, forest areas and agricultural areas have been placed in I category and are widely used. Level II categories are more specific in its scope and include coniferous, deciduous and mixed forests. Catogoery III is used quite rarely during local level studies. According to Narayan and Babu (1983), lot of soil is detached from the ground every year in India, with approximately 29 percent being carried away by streams into the ocean and 10 percent is being moved in to wetlands declining its water storage capacity. Peizhen et al. (2001), advocated that tectonic and climatic cycles are responsible for erosion, which is a worldwide phenomenon. Increased soil erosion has an impact on freshwater ecosystems by increasing the amount of sediment, nutrients, and pollutants that enter them from different sources. This may result in eutrophication, turbidity, and floods.

Jaiswal et al. (1999), conducted an analysis of changes in various land use/land cover classifications and came to the conclusion that forest acreage is shrinking as a result of growing pressure on it as a result of agricultural expansion, which is causing it to degrade. Williams and Langley (2001), observed that the quality parameters of water are affected by human activity are pH, conductivity, alkalinity (including dissolved oxygen), NO_3^-, phosphorous, silica, calcium (including $CaCl_2$), magnesium (including $MgCl_2$), sodium (including NaCl), and potassium (including KCl). Some of these factors, if they are beyond the normal permitted limits established by the WHO and the BIS may represent a health risk to individuals.

Gergel et al. (2002), examined a variety of ways in identifying human effects and concluded that land metrics gives a straightforward method of measuring human impacts. Skilodimou et al. (2003), argued that land use dynamics is an interplay caused both by human induced and natural processes influencing common biological systems in a positive direction. Any physical, chemical, or biological method can cause such a shift in the environment, for example, waste management, the establishment and the construction of agricultural irrigation supply dams, contamination and land degradation.

A comprehensive review of LU/LC change studies and their ecological responses was published by Jingan et al. (2005), they found that although biological factors influence patterns of landcover change at the macro level, the economy of people in the region are progressively becoming a main force to shape the environment.

Metzger et al. (2006), found that land dynamics has an important effect on the supply of numerous ecological services to people. Thapa and Rasul (2006), explored the impact of fluctuating public policies on cultivators, as well as the farmers' responses which included shifting land use methods and migrating to other countries. In this study, the premise that national policies and institutional structures, such as laws, have a major impact on farmers' land use choices, has been validated.

Lambin and Geist (2006), focused on the liaison connecting catchment land cover and water quality indices. Additionally, a given kind of land cover has an impact on a specific water quality indicator. As an example, multiple studies have shown that agricultural activities in the watershed are a significant determinant of nutrient and pesticide concentrations in the water bodies. Schneeberger et al. (2007), recognized the agents and driving factors behind land dynamics that were seen in Swiss Alps. In this study, the impact of land transformation on farmers as well as intercontinental, state, municipal, local planning agency, and non-official stakeholders were under trial.

Badar and Romshoo (2007), described that Dal Lake has been impacted both environmentally and hydrologically as a framework. Exceptional and spontaneous urbanization has occurred across the area in the recent decade. It has been observed that the untreated water is a cause of concern for the quality of water. The human interference and natural processes that have contributed in the contamination of lake are diverse and currently the lake is under accelerated eutrophication.

Yuksel et al. (2008), advocated that hydrological and other land surface cycles and phenomena may be predicted using geospatial models at a variety of geographical and temporal scales, which makes them very useful. Various researches conducted in this respect on Himalayan water bodies in valley have concentrated on their hydro-chemical and hydro-biological characteristics, with a particular emphasis on the latter. Qadri and Yousuf (2008), argued that Dal Lake is of great cultural and economic significance in Kashmir and one of the primary attractions for visitors, the inputs of (phosphorus and nitrogen) have significantly degraded its water quality over the last twenty years due to nearby developmental activities and other anthropogenic factors. These results are supported by (Jeelani and Shah, 2006; Singh et al., 2008; Yaqoob et al., 2008., Khan et al., 2012; Saleem et al., 2015).

Gupta et al. (2011), stated that human activities on the lake gradually degrade the water quality parameters, increase the number of harmful substances in the water, and cause the lake's catchment area to diminish. In Varanasi, the pond water is primarily impacted by the movement of pilgrims for ceremonial reasons and the disposal of waste materials originating from temples, water quality index plays a vital role in indicating the well-being of an aquatic body in addition to whether or not it is suitable for drinking and fishing (Sharma et al., 2009). Inspite of the fact that lake ecosystems are quite necessary they are increasingly threatened by anthropogenic influences and are at danger due to climate change.

Saleem et al. (2015), argued that overexploitation, toxic pollutants, and sedimentation are all factors playing their role in the decline of lakes and reservoirs across the globe. Future ecological and water asset specialists will be obliged to take significant steps to prevent lake and reservoir pollution. Shah et al. (2016), came to the conclusion that population growth beyond earths capacity is a cause of deteriorating environmental conditions. It is believed that eutrophication leads to the overgrowth of marine vegetation that reduces the supply of oxygen to the pond and eventually causes it to die. Because of the failure to take prompt action to minimize these terrible impacts on the lake, the water body will eventually die of its own infliction. In order to rescue this lake, there is an urgent need for strong action to be taken at the individual, community, and governmental levels. The Table 1 provides a brief description of the major works undertaken on the water bodies of Jammu and Kashmir.

Tadesse et al. (2017), observed that knowledge regarding changes in land use pattern is very useful for developing future natural resource management plans since it gives significant insights. When it comes to obtaining this kind of information, remote sensing data is an extremely powerful instrument. Geographical information systems and remote sensing have gained prominence in the more recent years, and they are now considered essential instruments in estimating the data (Shah et al., 2016).

Bhat et al. (2017), observed that changes in the LULC cycle have an impact on earth systems resulting in adverse ecological consequences. Similarly, Meraj et al. (2018), argued that environmental disturbances due to human interference has led to natural catastrophes that have created LULC shifts all over the globe, resulting in global ecological change as also advocated by Taloor et al. (2020). An interaction with the Dal dewellers was carried out (Fig. 2) to get the first-hand information about the Dal Lake services and benefits.

Fig. 2. Interaction with the Dal dewellers (right phograph: Mr. Bashir Shikari, president, fruitseller's association, Dal Lake).

Table 1. Reports on the degradation and conservation of Dal Lake

Name of Journal	Conclusion	Main highlights	Reference
Hydrobiologia	The study conducted by the author revealed that there are little dissolved solids in Kashmir lakes and are highly alkaline. These factors were due to high tourist flow and other anthropogenic factors.	Trophic status of lakes.	Vass (1980)
Internationale Revue der gesamten Hydrobiologie and Hydrographie	The authors studied the different mineral constituents of water and how they changed during the different seasons, and found that the concentration of these minerals was lowest during the growing season of macrophytes.	Nutrient load and the fluctuation during the different seasons of the year.	Trisal and Kaul (1983)
Proceedings of the Indian National Science Academy	The authors worked on the chemical composition of different aquatic plants such as *Myriophyllum* and found that the phosphate content was highest in the summer months.	Chemical composition of aquatic plants.	Kaul and Saraf (1985)
Environmental conservation	The nutritional values of macrophytes growing in Dal Lake was reported and a dry weight production of forty metric tons and large quantity of fish production during the study period was quantified.	Economic perspective of Dal Lake was presented.	Pandit and Qadri (1986)

International journal of water resources development	The research was carried on the limnological characteristics of water and how these parameters changed due to the direct incorporation wastes into the water body from the inhabitants and the houseboat owners.	Sustainable management of Dal Lake.	Trisal (1987)
Hydrobiologia	The authors worked on the dissolved organic carbon and found that these values showed peak during winter and minima during summer.	Dissolved organic carbon of Dal Lake.	Koul and Kaul (1988)
Archiv für Hydrobiologie	The authors calculated the energy content of different macrophytes belonging to floating and submerged types and found that the floating type macrophytes accumulated maximum energy in their leaves.	Energy content of different macrophytes groups.	Handoo et al. (1988)
Internationale Revue der gesamten Hydrobiologie and Hydrographie	The authors worked on the phosphorus budget of Dal Lake and found that the lake has high phosphorus content and high retention also. They correlated the phosphorus retention with in the lake with that of flushing.	Phosphorus budgeting of Dal Lake.	Ishaq and Kaul (1990)
Hydrobiologia	The authors found that the nutrient enrichment of Dal Lake has caused enormous macrophytic growth as such is hampering the recreational activity which negatively affect the lake wellbeing.	Deweeding of the lake is suggested for good water transparency and aesthetic appeal.	Zutshi and Ticku (1990)

International Journal of Ecology and Environmental Sciences	The authors worked on the limnology of Dal Lake and suggested measures for its conservation.	Conservation of lakes.	Ticku and Zutshi (1991)
Environmental conservation	During their study the authors found the presence of euglenoid bloom in the center of the lake which imparted red colour to the water during the summer months.	Red bloom in Dal Lake.	Khan (1993)
Journal of the Indian Society of Remote Sensing	The authors analyzed the Indian remote sensing and spectral data to suspended solids in the Dal Lake and found a correlation between suspended solids and visible wavelength bands.	Suspended solids in Dal Lake.	Wani et al. (1996)
Pollution research	The authors worked on the effect of dredging in the Dal Lake and found that the concentration of nitrate nitrogen and total phosphorus content decreased after dredging while as the content of ammonical nitrogen and orthophosphate content increased.	Effect of dredging on Dal Lake.	Kundangar and Abubakr (2001)
Water Pollution	The authors studied the role of anthropogenic factors on the water characteristics of Dal Lake. The study revealed that the different components of water such as nitrate and orthophosphate showed higher range and a low transparency value.	How the water quality parameters are affected by the anthropogenic factors.	Ara et al. (2004)

Forest	The authors used modern techniques such as pollution load model and the GIS to find out the different sources of pollutants which enter the lake and assessed the quality of water with respect to the different parameters.	Quantifying pollution load in Dal Lake.	Badar and Romshoo (2007)
Himalayan Ecology and Sustainable Development	Dal Lake has been impacted both environmentally and hydrologically as a framework. Exceptional and spontaneous urbanization has occurred across the area in the recent decade. It has been determined that the waste water that has not been treated properly is a cause of concern for the quality of water	Due to urbanization the ecology of Dal Lake has been influenced.	Badar and Romshoo (2007)
Journal of Himalayan Ecology and Sustainable Development.	The authors observed that the water quality of the lake has deteriorated from the last many years due to the non-point pollution sources and was examined using the modern technologies.	Non point pollution sources of Dal.	Badar and Romshoo (2007)
PhD.Thesis	While Working on the economic evaluation of Mansar lake, Jammu, a detailed overview of the goods and services which are derived from the lake was presented besides the different obtained from the lake using Cost of Illness and the Tragedy of commons. This study was conducted by a survey method involving questioners such as CVM and TCM.	CVM and TCM survey	Zuber (2007)

World Lake Conference	The Dallake has huge cultural and economic importance and the primary fascination for travelers in Kashmir, the anthropogenic elements (phosphorus and nitrogen) have significantly diminished its water index quality during the previous twenty years due to the illegal constructions near lake	The anthropogenic activity needs to be minimized on the Dal Lake for proper conservation	Qadri and Yousuf (2008)
Proceedings of Taal	While working on the freshwater ecosystems of Kashmir Himalaya and how the change in global climate impact the diversity of these biotypes, it was tried to find out how chemical characters of water bodies change due to human induced pressure	Change in the abiotic properties of water due to human induced pressure,	Jeelani and Kaur (2008)
Nature Environment and Pollution Technology	While working on the Dal Lake the authors found that the pollution is increasing at a higher rate inspite of the restoration measures taken by the Govt. They found that the changes in the water chemistry effects the macrophye composition of the lake. The authors suggested the measures to be taken for the conservation of lake.	Changes in the chemical properties of water due to increasing pressure on Dal Lake.	Kundangar and Abubakar (2008)
International Review of Hydrobiology	The authors reported the phosphorus concentration in Dal Lake is increasing beyond its tolerance range which in turn is the primary cause of eutrophication. The paper suggests the reduction in the external input of phosphorus into the lake for long lasting use.	Nutrient enhancement in lakes and its impact.	Solim and Wanganeo (2008)
World Geography	The authors worked on the soil erosion and its impact on the water quality once it is transported to the lakes and rivers.	Soil erosion and its impact.	Sheikhg and Shahg (2008)

Ethnobotany and Medicinal Plants of India and Nepal	During his study on the ethnobotany of some important macrophytes growing in Dal Lake and other places, the author concluded that aquatic flora has been completely ignored. They got the ethnomedicinal importance of macrophytes from local people living in the vicinity of lake.	Ethanomedicinal properties of Dal Lake plants.	Kak (2009)
Nature, Environment and PollutionTechnology	The authors studied the importance of some common macrophytes species of Dal Lake like *Phragmites communis* and *Typha angustata*. They came to the conclusion that macrophytes provide important functions like increase in dissolved oxygen and decrease in conductivity besides acting as absorbents of pollutants and enhancing the quality of water.	Importance of macrophytes in increasing the beauty of the water body and enriching its health status.	Abubakar (2010**)**
Ecological Appraisal for the Indian Subcontinent	While working on the alien aquatic species of macrophytes and how these groups of macrophytes outcompete others because of their high invasive character	Invasiveness of species	Shah and Reshi (2011)
Control pollution	The authors reported the chemical parameters of water in Dal Lake and observed that all the parameters showed higher values especially near the house boat areas and an abundant macrophytes growth indicating that the pollution was mainly due to habitation with in the lake.	Luxurious growth of macrophytes near the houseboats.	Bhat and Ali (2012)

Journal of Ecophysiology and Occupational Health	The authors studied the nitrogen content in the Dal Lake and attributed it to the anthropogenic activities in the catchment. The values of nitrate, nitrite nitrogen was found to be increasing during the study period	Increased nitrogen content in the Dal Lake due to biotic pressure.	Lone et al. (2012)
International Journal of Environmental Sciences	The author observed the aesthetic appeal of the Dal Lake due to its good waters, presence of house boats and thee mountains and Mughal gardens which surround it and increase the economy of the state.	Dal Lake conservation.	Shah (2012)
Ecology and Environment	The authors reported the variation in water quality of Dal Lake and found a significantly good variation in some important parameters of water such as BOD and COD. It was observed that agricultural and surface runoff was responsible for declining of water quality.	Changes in BOD and COD parameters of water in Dal Lake.	Najar and Bashir (2012)
International Journal of Physical and Social Sciences	The author worked on the linkage between economy and environment in Dal Lake and observed that the lake provides different benefits, but the carrying capacity of the lake need not to be compromised and the misuse of resources need to be checked and the management of water bodies undertaken for the overall benefit of the society.	Linkage of economy and environment and the sustainability.	Rather (2012)
Environmental Science and Engineering	The researchers worked on the natural resources derived from the Dal Lake and the primary among them were the water resources which are used for drinking and irrigation purposes and thus help in the uplifting of local economy by way of recreational and other aspects.	Natural resources derived from Dal Lake.	Wani et al. (2013)

African Journal of Environmental Science and Technology	The authors worked on the limnological parameters of water in Dal Lake and found that the most common parameters of water increased due to anthropogenic stress. They classified the lake as eutrophic due to its shallow nature	Limnological properties of water in Dal Lake.	Mushtaq et al. (2013)
International Research Journal of Environmental Science	The authors examined the abiotic properties of water in the Nigeen lake and found that there is the transport of pollutants from outside the lake and inside taking place.	Abiotic properties of Nigeen lake.	Shah and Shah (2013)
International Journal of Environmental Science	The authors worked on the waste producing units in the Dal Lake vicinity and its impact on the ecology of Dal during the peak tourist season which negatively effects its beauty and quality.	Tourist activities around Dal Lake and its impacts.	Wani and Shah (2013)
Natural science	The study undertaken by the authors found that the waters of Dal Lake are eutrophic and the values of pH, conductivity and other values are on the higher side and needs an immediate attention of the Govt. for its conservation.	Chemical parameters of water.	Khan et al. (2013)
Limnological Review	During their study the authors worked on the aquatic macrophytes of Dal Lake and tried to find out the factors which effect the distribution pattern of macrophytes. They found that light and temperature are the	Effect on distribution pattern of macrophytes due to	Dar et al. (2014)

	important factors determining the growth of macrophytes, the change in water levels also effect the distribution process	changing water quality parameters.	
International Journal of Engineering Research and General Science	The authors observed that the nitrate and phosphate content of the lake increased from last many years because of the use of these fertilizers in the floating gardens and in the vicinity of Dal.	Nutrient enhancement of the Dal Lake.	Khan et al. (2014)
Journal of Himalayan ecology and sustainable development	The authors reported the limnological characteristics of water at three stations and found that the values changed minutely from one study site to the other. Their study revealed that there is a slight improvement in the quality of water due to installation of treatment plants. Again, the cause of pollution was found to be untreated sewage.	Physicochemical properties of water in Dal Lake and the use of water treatment plants.	Parvez and Bhat (2014)
International Journal of Advanced Information Science and Technology	Using the advanced technologies, the authors tried to find out the anthropogenic impact on Dal Lake and the changing land use pattern.	Land use change of Dal Lake.	Shah et al. (2014)
Limnological Review	While working on the distribution pattern of macrophytes and the dominant environmental factors which influence their abundance such as light, temperature, nutrient conditions and sediment	Interspecific competition and herbivory among different groups of plants.	Naseer et al.(2014)

	constution. It was found that competition and herbivory too have a role in determining the success of a particular species.		
American International Journal of Contemporary Scientific Research	The authors carried the comparative analysis of macrozoobenthos in the dredged and non-dredged sites of the lake and computed the results	Effects of dredging on Dal Lake.	Mushtaq et al. (2014)
Research Journal of Environmental Sciences	The authors worked on the diversity of periphytic algae in the lake and classified them into different groups like chlorophyceae and cyanophyceae and bacillarophyceae and thirty-one taxa.	Diversity of periphytic algae in Dal Lake.	Pandit et al. (2014)
Ecology Environment and Conservation.	The authors carried out the important water parameters of Dal Lake and observed that most of them were on the higher side due to pollution of the lake.	Physico chemical properties of Lake.	Akthar et al. (2015)
International Journal of Applied Research	The authors worked on the abiotic status of Nehru Park and Ashai bag station and found that Ashai bag was more polluted when the BOD, COD and other parameters were taken into consideration, and suggested some remedial measures for control of pollution.	Pollution at the different sites of Dal Lake.	Bhat and Dar (2015)
International Journal of u-and e-Service,	The authors took an extensive review of the different factors which are affecting the Dal Lake and found that due to increasing pressure	Declining the area of Dal Lake because of human activities.	Ali (2015)

Science and Technology	the lake is decreasing in its area because of the apathy of the Govt. and unhealthy ecological measures.		
Journal of Environmental. Protection and Sustainable Development.	The authors investigated the composition of sediments of Dal Lake and found that the pH of the sediment was correlated with conductivity and nitrate content. The values of chlorides and sulphates varied from site to site. The study suggests the increasing population was responsible for the water quality deterioration.	The sediment composition of Dal Lake and its correlation with different water parameters.	Mushtaq et al. (2015)
South Asian Law and Economics Review	The researcher worked on the economic upliftment of people by the Dal Lake and the impact it has created on the lives due to lock down when no economic activity took place in the Kashmir valley. The study stresses on the need to put up a road map for the people who directly make their living from Dal Lake by acting as tourist guides and selling day to day utilities in the lake banks.	Role of Dal Lake in uplifting the economy of the local people.	Mohsin (2016)
Doctoral Dissertation	Remote sensing data is an extremely powerful instrument. Geographical information systems and remote sensing process have achieved prominence in the previous years, and they are now considered essential instruments in estimating the data.	Use of modern technology can help in the effective estimation of scientific data	Shah et al. (2016)
Pharmacognosy and Phytochemistry	It is believed that changes in the LULC cycle have an impact on earth systems resulting in adverse ecological consequences.	Scientific management of LULC pattern.	Bhat et al.(2017)

Journal of Environment and analytical Toxicology	The study on different chemical parameters of water at the different basins and was conducted and it was found that Telbal and Jogilankar sites were most polluted because of the agricultural fields in their vicinity.	Pollution at different basins of Dal Lake.	Lone et al. (2017)
Limnology	The study on the clonal growth of *Nymphoides peltatum* was carried out to investigate if the changes in water levels have any effect on the growth of this species. They found that water depth has an important role in the number of ramets and the reproductive structures of this species in the Kashmir lakes.	Invasiveness of *Nymphoides peltatum*.	Khanday et al. (2017)
International journal of scientific & engineering research	The authors observed that the water quality of the Dal Lake has declined during the last three four decades which decrease the appeal of lake. The study finds the decrease in dissolved oxygen and an increase in BOD. They also reported the plastic pollution in thin the Dal Lake.	Decline of water quality during the last four decades due to population load.	Dar et al. (2017)
Journal of Environment and Analytical Toxicology	The authors worked on the physico-chemical properties of Dal Lake at different basins and found that the Telebal basin was most polluted due to agricultural wastes and higher tourist footfall.	Change in water quality at the Telebal basin of Dal Lake.	Lone et al. (2017)
Current Environmental Engineering	The authors worked on the limnological features of Brarinambal site of Dal Lake and found that the water quality index has changed post 2014 floods. The examination of the different parameters of water	Water characteristics of Brarinambal site of Dal Lake.	Mukhtar and Bhat (2017)

	such as permeability index and sodium absorption ratio show the waters are fit for the irrigation of fields and not for drinking.		
Ecology Environment and Conservation.	The authors observed that the bacterial load increases during different seasons at the different stations of Dal Lake, and during the current study Hazratbal site showed highest bacterial load indicating its high trophic status.	Bacterial load in water.	Malik et al. (2017)
Pacific Business review International	The authors worked on the tourism related activities which enhance the standard of living and the tourist infrastructure when the people intend to visit the sound tourist places.	Tourist attractions and the eco-tourism.	Kaushal and Awastthi (2018)
Journal of Environmental Treatment Techniques	Studies on the heavy metal load of Dal Lake waters was conducted. The lake waters were analyzed by atomic absorption spectrophotometer. It was found that the heavy metal concentrations were below the limits. Hence the monitoring of the lake to taken care on regular basis	Heavy metal concentration in Dal Lake using AAS.	Mukhtar and Chisti (2018)
Journal of Earth science and Climate Change	The Study conducted over the years on Dal Lake found that the changes have occured in Dal Lake, the data has been collected from various stations and analysis was performed. According to the data collected, the water quality of Dal Lake has substantially worsened in recent years.	Changes in water quality.	Mushtaq et al. (2018)

Stochastic Environmental Research and Risk Assessment	The calculation of WQI values suggested that these values were found to be greater during different seasons (winter and summer), indicating a seasonal pattern. WQI results showed that the whole lake water is unsafe for human use. It was discovered that coliform bacteria were the principal cause responsible for the poor quality of water.	Change in water quality index	Khanday et al. (2018)
Indian Journal of Ecology	The authors worked on some important parameters of water such as transparency, conductivity, BOD, COD and found that all the values showed higher values during the study period.	Limnological characteristics of water.	Jamila and Yousuf (2018)
Environmental Marketing and Assessment	While studying the higher doses of HMs from some fish species growing in Kashmir Himalayas it was found that they magnify at the different trophic levels once they enter into the food chain**.**	Magnification of HMs.	Mehmood et al. (2019)
International Journal of Environment and Climate Change	The authors put to fore the economic potential of two water bodies Jehlum and Dal Lake and found the most of the people are involved in water related activities and drive their livelihood by Vegetable cultivation and boating and fishing activities with in the lake. Due to the increased tourist arrivals the Dal Lake has come under pressure and the measures for its conservation need to be taken.	Economic upliftment potential of Jehlum and Dal Lake.	Wani et al. (2019)

International Journal of Communication System	The authors worked on the impact of effluent of SWT in to the Dal Lake and found that some important parameters such as conductivity and orthophosphate levels have increased and effecting the water quality.	Sewage treatment plants in the Dal Lake vicinity and the impact of effluent.	Chasho et al. (2020)
International Journal of Ecology and Environmental Sciences	The authors undertook the study during the three seasons of the year and found that the water quality has deteriorated due to agricultural activities and the increased population there by effecting the lake development.	Impact of agricultural activity on the Dal Lake waters.	Firdous et al. (2020)
Frontiers in Environmental Science	The authors worked on the major water bodies of Srinagar which are the source of sustenance to the local people. However, due to unsustainable use the degradation of these water bodies is taking place. Introduction of alien species and climate change are the major threats to these water bodies.	Sustaining the economy of the local people by the services of Dal Lake.	Dar et al. (2020)
Journal of Travel and Tourism Marketing	While investigating the limnological features of Dal Lake. It was argued that due to anthropogenic activities and changing land use pattern in the area, vegetation has shown a considerably negative change over the years, which is consistent with the ongoing contamination of the water quality index of the lake	Change in vegetation cover of Dal Lake.	Rather (2020)

Uttar Pradesh Journal of Zoology	The water quality index of Dal Lake and some other parameters have crossed the desired limit and as such not suitable for drinking purposes. The study suggested that monitoring the quality of the lake water is needed for the conservation of the lake	Monitoring the water quality of Dal Lake for drinking purposes.	Dar and Srivastava (2021)
International Hospitality Review	The researchers worked on the economic aspects of the Dal Lake and computed the different services provided by it in the form of water extraction, vegetable cultivation and tourist arrivals, there by indicating that the lake has huge potential to restore the economic condition of the state	Services provided by the Dal Lake to raise the standards of local people.	Shah and Islam (2021)
Asian Journal of Biodiversity	The authors worked on the macroinvertebrate community of water with respect to the pollution pressure. They also assessed the abiotic status of waters.	Macroinvertebrate community of waters in Dal Lake.	Gudoo et al. (2021)
Environmental Monitoring and Assessment	The authors reported the importance of Dal Lake and the different services provided to the people. However, due to increasing population untreated sewage enter into the lake and change its chemical properties. It was observed that the dissolved oxygen content has decreased during the past years and a corresponding increase in the hardness of water.	Importance of Dal Lake with regard to the different services derived from it.	Kumar et al. (2022)

Sustainabiliy and Biodiversity Conservation	The researchers studied the nutrient content of some important macrophytes of Dal Lake like *Nelumbo nucifera* and *ceratophyllum demersum* and concluded that highest values of protein content were present during summer months of the year which are the best growing seasons.	Nutrient status of some important macrophytes in Dal Lake.	Rather et al. (2022)

2.2. Macrophytes observed in the Dal Lake

The macrophytes present in the Dal Lake were collected and identified at Govt Degree College Anantnag by the curator and the plants were classified into different groups (Table 9).

Here is the brief review of macrophytes growing in the different wetlands of the world and India. Sondergaard and Moss (1998), studied the widespread presence of phytoplankton in lakes and the essential relevance of these biotypes for normal functioning and balance of these ecosystems. Its relevance for water quality, as well as its rising dominance as the major producer in shallow lakes at the cost of submerged macrophytes species, is the result of increased nutrient inputs into the lake ecosystems. In many cases, macrophytes have entirely vanished, and nutrients are so high that it is impossible to imagine any bottom-up regulation of phytoplankton by the use of phosphorus. Barko et al. (1998), reported how dominance of aquatic macrophytes can be increased to the excessive nutrient loading such as phosphorus.

Khan et al. (2004), worked on the Hokersar Wetland and presented the current scnerio of the water body such as macrophyte structure, hydrology and rate of sedimentation thereby determining the overall health of the wetland. Vardanyan et al. (2006), studied the role of macrophytes in accumulating the HMs thereby leading to the purification of water.

Jeelani and Kaur (2008), worked on the freshwater ecosystems of Kashmir Himalaya and how the change in global climate impact the diversity of these biotypes, they tried to find out how chemical characters of water bodies change due to human induced pressure. Anjum and Mahajan (2009), Worked on the Hokersar wetland and studied the quantative distribution of macrophytes and their classification into the different categories such as Submerged, Rooted floating, Emergent and free-floating types. Talevska et al. (2009), discussed macrophyte vegetation found in the three lakes that are divided into zones of different sizes (belts). The richness of macrophytes varies in each of the lakes, and it is a direct result of the differences in height, lake surface, and lake depth.

Santosh and Satya (2010), Studied the dominating role of physicochemical factors in determining the success of macrophytes and their role in boosting the economy, and a medium for treating different diseases among the local population. Lawniczak et al. (2010), conducted studies on the polymictic lake of Central-Western Poland, Over the period 1974 to 2002, the level of water in the reservoir was controlled for agricultural purposes with a mean amplitude of 0.85 meters. The fall in the level of water has a detrimental impact on biomass quality and quantity, and concentrations of nutrient in the environment. *Typha angustifolia* and *Glyceria maxima* were among the plants that suffered the most from the decrease in water levels. Other species, such as *Phragmites australis* and *Carex acutiformis*, were least effected.

Shah and Reshi (2011), worked on the alian aquatic species of macrophytes and found that how these groups of macrophytes outcompete others because of their high invasive character. Bhaskaran et al. (2013), observed that like other forms of macrophytes free floating macrophytes are also needed for their role in remediation of per chlorate. Naseer et al. (2014), studied the distribution pattern of macrophytes in Kashmir and the dominant environmental factors which influence their abundance such as light, temperature, nutrient conditions and sediment constution. They were of the opinion that competition and herbivory also play a role in the success of a particular species.

Ahmad et al. (2014), studied the phytoremediation potential of *Phragmites* species in extractingg the excess of HMs from Hokersar. Phytoremediation is the cheapest form of natural water purification. Shah et al. (2014), presented a consolidated account of invasive macrophytes growing in the wetlands of Kashmir Himalayan and the need for the conservation and awareness about these alien species. Bashir et al. (2014), observed how the fitness of the plant can be increased by clonality which is present in some forms of aquatic macrophytes.

Dipankar et al. (2015), studied the quantative macrophytic diversity and monitoring of ecological quality by calculating the important value index of some important macrophytes types in the Oxbow Lake ecosystem. Ahmad et al. (2016), **s**tudied the importance of aquatic flora in the bioremediation of HMs there by playing an active role in the purification of water bodies, the waters of which otherwise become very toxic due to excessive load of HMs leading to various forms of human diseases.

Mukherjee et al. (2017), studied the invasive exotic aquatic species in Ranchi, India, and found that the invasive species due to their capacity to invade the habitats lead to the decline in endemic aquatic diversity. They prepared the list of invasive plant species growing in the waterbodies of the district.

Deepika and Sheikh (2019), documented the aquatic macrophytes in Mansar Lake Jammu and reported some 25 species belonging to different genera, their investigation ended with a strong note that the diversity of macrophytes is declining because of pollution problems. Lolu et al. (2019)**,** studied the input and sequestration potential of aquatic macrophytes from Hokera a Ramsar Site in Kashmir.Their findings of carbon sequestration are with regard to 12 macrophytes in the water body.

Alahuhta et al. (2020), revealed that environmental variables for species richness and species composition were responsible for the greatest amount of variance among helophytes and hydrophytes. In spite of this, dispersion-related variables were also significant, however they were less significant than environmental factors. The characteristics associated with dispersion were also more essential for hydrophytes than for helophytes.

Pandit and Qadri (1986), studied the nutritional values of macrophytes growing in Dal Lake and reported a dry weight production of forty metric tons and large quantity of fish production during the study period. Kundangar and Abubakar (2008), worked on the Dal Lake and found that the pollution is increasing at a higher rate in sipite of the restoration measures taken by the Govt. They found that the changes in the water chemistry effects the macrophye composition of the lake. The authors suggested the measures to be taken for the conservation of lake.

Kak (2009), worked on the ethnobotany of some important macrophytes growing in Dal Lake and other places, they concluded that aquatic flora has been completely ignored. They got the ethanomedicinal importance of macrophytes from local people living in the vicinity of lake.

Abubakar (2010**),** studied the importance of some common macrophytes species of Dal Lake *like Phragmites communis* and *Typha angustata*. They came to the conclusion that macrophytes provide important functions like increase in dissolved oxygen and decrease in conductivity besides acting as absorbents of pollutants and enhancing the quality of water.

Parvez and Bhat (2014), studied the changes in water chemistry at the different basins of Dal Lake they observed that the different basins varied slightly with respect to the pollution level. They concluded that the parameters of water changed due to sewage pollution and the unscientific usage of floating gardens thereby changing the macrophytes composition of lake.

Dar and Pandit (2014), worked on the aquatic macrophytes of Dal Lake and tried to find out the factors which effect the distribution pattern of macrophytes. They found that light and temperature are the important factors determining the growth of macrophytes, the change in water levels also effect the distribution process.

Rather and Nazir (2015), worked on the biochemical composition of some important macrophyte species in Dal Lake and presented a consolidated account of therent constituents of proteins, lipids present in them.

Bhat and Dar (2015), investigated the biochemical features of *Nymphoides peltatum* at the designated sites of Dal Lake during different seasons of the year and observed that chlorophyll content, protein content and the starch content were higher in the favorable seasons and lowest in the unfavorable seasons such as winter. The macrophytes growing in the lake are used as both food and fodder.

Khanday et al. (2017), worked on the clonal growth of *Nymphoides peltatum* and tried to investigate if the changes in water levels have any effect on the growth of this species. They found that water depth has an important role in the number of ramets and the reproductive structures of this species in the Kashmir lakes.

Talwar and Tania (2018), worked on the Dal Lake and noted that the lake provides a lot of ecological benefits such as macrophytes harvesting, fish cultivation and tourist attraction. However, due to extreme pollution the bloom formation takes place decreasing the diversity of the lake. Kumar et al. (2022), worked on the Dal Lake, Srinagar and observed that the excessive sewage and the sediment from the nearby areas have caused the pollution in the water body. The change in the water parameters is clearly depicted from the physico-chemical properties of water, which are more aggravated by the houseboats and the shikaras present in the lake. As a result, there is a shift in the macrophytes pattern with in the lake.

Rather et al. (2022), studied the nutrient content of some important macrophytes of Dal Lake like *Nelumbo nucifera* and *ceratophyllum demersum* and concluded that highest values of protein content were present during summer months of the year which are the best growing seasons. Shafqat et al. (2023), worked on the antioxidant properties of twenty different species of macrophytes by using polymerase chain reaction amplification.

Parray et al. (2021), studied the dominant macrophytes and abiotic features of Dal Lake and Chatlam wetland and presented the consolidated account of macrophytes growing in two lakes and the changing limnological features of these two water bodies due to anthropogenic stress and suggested some conservation measures.

2.2. Evaluation of Physico chemical properties of water in Dal Lake

The state of J&K situated in the northern Himalaya side, is enriched by a plenty of lakes, mountains and alpine areas. The most important aspect of the valley of Kashmir is large number of lakes which are ordered into frosty, pine forests dependent on their origin, altitude variation and the biotic wealth dweling in these water bodies (Zutshi et al., 1972; Kaul, 1977 and Pandit, 1996, 1999). In the lakes of Kashmir eutrophication and declining of lake biological health is an ongoing process from the past 10-30 years, together with an increased civilizational development in the vicinity of the lakes (Pandit, 1998). Since the industrial advancement in the valley of Kashmir is not very high, the principal factors which contributed to the deterioration of lake quality were land-use changes, improper urbanization, expanded soil disintegration and unscheduled use of pesticides and fertilizers (Badar and Romshoo, 2007a, b). Therefore, the greater part of the lakes in the Kashmir valley displays nutrient enrichment (Kaul, 1979; Khan, 2008), which is evidenced by high macrophytic growth (Jeelani and Shah, 2006). Dal Lake, a support of Kashmiri progress has solid associations with the socio-financial aspects of the territory of J & K in India. With its multi-layered environment and glory, this lake has been a focal point of fascination for public and global travelers for quite a long time.

Expanded overflow, disintegration and ensuing sedimentation in the catchment of the lakes have come about in expanded turbidity, diminished light entrance and transparency of the lake (AHEC, 2000). Accordingly, these exercises are choking out the lake and declining its water content (Solim and Wanganeo, 2008). According to Dainda, (1990), the Dal Lake occupied an area of 22 km2 till 1940, and now has reduced to only 11.5 km2 (Badar and Romshoo, 2007a, b). A large part (20%) of the lake has only floating gardens decreasing the water cover to 59% of the lake area (Khan, 2000).

It has been seen that the land use types around the catchment significantly influence the hydrological reaction such as surface runoff (Breuer and Huisman, 2009). Such changes in run off designs thus bring about serious natural ramifications like expanded disintegration, sedimentation and nutrient loadings there by upseting their biological strength (Heathwaite et al., 1990).

Soil erosion is an unpredictable powerful interaction by which surface soils are separated, moved and collected in a far-off place bringing about openness of subsurface soil and sedimentation in repositories. Narayan and Babu (1983), have found that in India around 5334 metric tonns (16.4 t ha^{-1}) of soil is detached every year, about 29% is moved by the streams into the ocean and 10% is deposited in to the reservoirs.

The Human Impact on natural environment, studied by Andrew Goudie (2000), describes how humans have influenced these aquatic ecosystems, although, this is impossible to demarcate between the different roles performed by humans and the role played by the climatic changes. According to Parizzi et al. (2001), the danger of water pollution has grown because of the growing number of tourists visiting the region. Kanth and Bhat (1997), conducted a comparison of the tourist arrival and chemical properties of Dal Lake water in 1997. A number of authors, including Karan and Mather (1985), argued that environmental issues associated with tourism are ascribed to large numbers of tourists, the use of fuel, trekking, as well as effluent disposal and concluded that these practices should be best managed by following certain procedures to avoid environmental deterioration.

Nanthini et al. (2001), observed the different chemical parameters of water such as turbidity, chlorides, nitrates, phosphates, sulphates, conductivity and pH to evaluate the drinking criteria of water. Ara et al. (2004), studied the chemical composition of Dal Lake waters and found that the common water parameters such as nitrate, orthophosphate, calcium, magnesium and sodium were found to be on the higher side because of the anthropogenic pressure.

Zacharias et al. (2004), showed that change in the land cover pattern have a substantial impact on the water quality of nearby area, and that the geographic information systems is beneficial in analyzing this phenomenon. They conducted an assessment of vegetation wealth by GIS methods, and identified the socio-economic elements contributing to deforestation. In the pastoral German mountains, Hietel et al. (2005), employed the same parameters as were used in the urban areas.

Pandit et al. (2012), discovered an alarming impact of hydropower development on terrestrial biodiversity. They came to the conclusion that the Western Himalaya is more likely than the Eastern Himalaya to experience significant forest cover loss as a result of uncontrolled human interference.

Mushtaq et al. (2013), studied the different chemical parameters of water at the four stations of Dal Lake. The lake was found to be eutrophic because of its shallow nature. The common water parameters such sulphate, phosphate, nitrate and chloride were found to be higher than the normal range.

Mushtaq et al. (2018), compared data over the years to study the changes taken place in the Dal Lake, the data has been collected from various stations and the statistical analysis was done. According to the data collected, the water quality of Dal Lake has substantially worsened in recent years.

Khanday et al. (2018), calculated WQI and these values were found to be greater during different seasons (winter and summer), indicating a seasonal pattern. WQI results showed that the whole lake water is unsafe for use. It was discovered that coliform bacteria were the principal cause responsible for the poor quality of water. Stopping the direct influx of polluted sewage from different house-boats, as well as from communities within and around the lake's periphery, might help to alleviate the situation. This study effort is intended to guide methods for improving the water quality of this socioeconomically significant lake in the Indian Himalayas, and it is anticipated that the results will do so. The hydrogeochemical findings revealed that the water of wetland is usually alkaline in character, having moderate electrolyte concentration. The coefficient of correlation and the statistical study revealed lithology of the catchment has the dominant role on the composition of the lake's water quality. It is believed that the time of water inside the Nigeen lake contributed to the high average concentrations of Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-, and NO_3^- found there. A significant contributor to the deterioration and eutrophication of the Lake is the increasing inflow of P, NO_3^-, and SiO_2 into the water. It was discovered that the lake is under a great deal of stress as a result of urbanization, and that thorough measures are required to clean all wastewater before it is discharged into the waterbodies. The long-term survival of lakes is necessary to foster a strong, autonomous, and responsible connection between people and their natural ecosystems.

Ayaz et al. (2019), accounted an estimate of 234 macrophyte species identified in all three areas of the state. The species were identified in both primary and secondary sources. The most diverse group of macrophytes were the emergent macrophytes followed by floating leaf-type, rooted macrophytes, submerged, and free floating macrophytes. The Kashmir valley had the highest number of macrophytic species reported, while the Ladakh area had the lowest number, with just 41 species documented there. In recent years, lakes that have been subjected to growing eutrophication have been overrun, mostly by aggressive interlopers such as *Typha* sp., *Phragmites australis*.

Rather (2020), investigated the limnological features of Dal Lake. It is argued that due to anthropogenic activities and changing land use pattern in the area, vegetation has shown a considerably negative change over the years, which is consistent with the ongoing contamination of the water properties of the lake. The forest cover has shown a very negative change since 1980. From 1990 to 2018, there was a rise in all forms of eutrophication. At the same time, it was discovered that the loss in forest, agricultural, and floating gardens have caused negative impact on all water quality parameters. Frau et al.

(2021), studied the limnological features of 21 wetlands of America with regard to the changes in environmental protection over the years and presented a detailed report, the response of these water bodies to the changing climatic conditions was reported.

Parray et al. (2021), studied the comperative macrophytes and physico- chemical features of the two wetlands such as Dal Lake and Chatlam.The community characters of macrophytes and the important chemical parameters of water were analyzed and conservation measures for these two water bodies were suggested. A flow char showing the importance of Dal Lake with regard to the different sevice and the main sources of pollution is given under in the (Fig 3 and 4).

Ara et al. (2004), studied the role of anthropogenic factors on the water characteristics of Dal Lake. The study revealed that the different components of water such as nitrate and orthophosphate showed higher range and a low transparency value. Solim and Wanganeo (2008), reported the phosphorus concentration in Dal Lake is increasing beyond its tolerance range which inturn is the primary cause of eutrophication. The paper suggests the reduction in the external input of phosphorus into the lake for long lasting use.

Bhat and Ali (2012), worked on the chemical parameters of Dal Lake water and observed that all the parameters showed higher values especially near the house boat areas a an abundant macrophytes growth indicating that the pollution was mainly due to habitation with in the lake. Lone et al. (2012), studied the nitrogen content in the Dal Lake and attributed it to the anthropogenic activities in the catchment. The values of nitrate, nitrite nitrogen was found to be increasing during the study period. Najar and Bashir (2012), studied the water quality variation in Dal Lake and found a significantly good variation in some important parameters of water such as BOD and COD. It was observed that agricultural and surface runoff was responsible for declining of water quality. Mushtaq et al. (2013), worked on the limnological parameters of water in Dal Lake and found that the most common parameters of water increased due to anthropogenic stress. They classified the lake as eutrophic due to its shallow nature. Mushtaq et al. (2015), investigated the Dal Lake sediment composition of and found that the pH of the sediment was correlated with conductivity and nitrate content. The values of chlorides and sulphates varied from site to site. The study suggests the increasing population was responsible for the water quality deterioration.

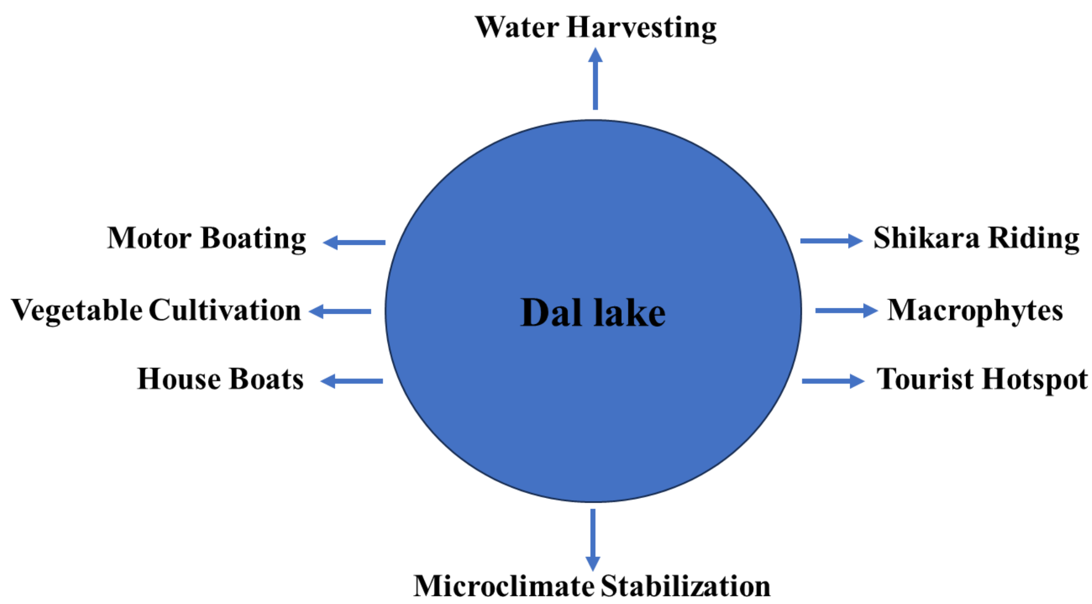


Figure 3: Importance of Dal Lake.

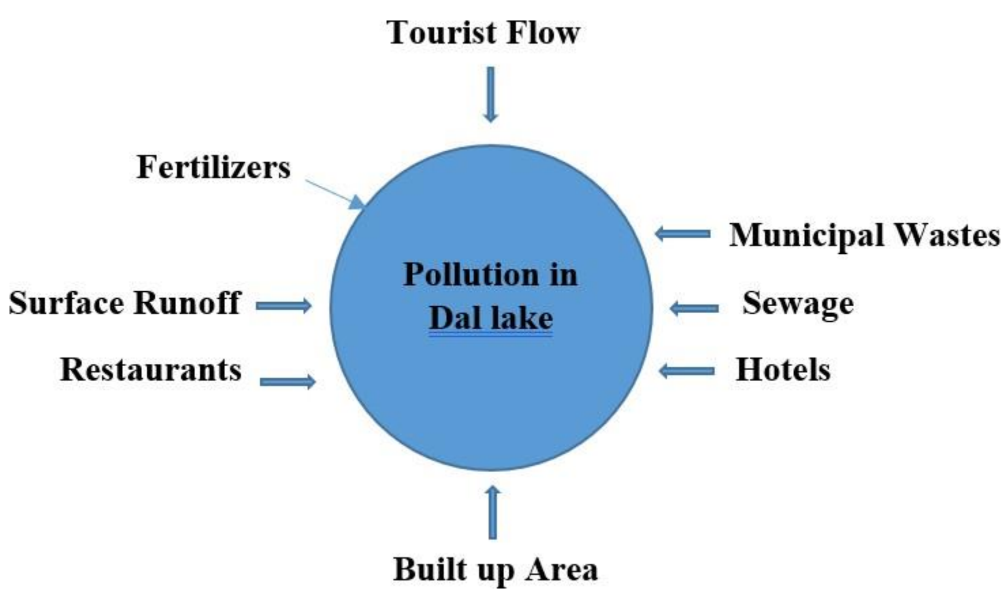


Figure 4: Different sources of pollution in Dal Lake.

Bhat et al. (2017), worked on the nutrient load in Dal Lake and found that the values of nitrate showed peak during the autumn and the values of phosphorus peaked during summer season. Their study found that the Dal Lake is in mesotrophic stage.

Dar et al. (2017), Observed that the Dal Lake water quality has declined during the last three four decades which decrease the appeal of lake. The study finds the decrease in dissolved oxygen and an increase in BOD. They also reported the plastic pollution in thin the Dal Lake. Lone et al. (2017), worked on the physico-chemical properties of Dal Lake at different basins and found that the Telebal basin was most polluted due to agricultural wastes and higher tourist footfall.

Dar et al. (2020), worked on the water parameters of Nigeen lake by analyzing the major water parameters and found that most of the chemical parameters are with in the range as per the (WHO). However, the lake was found to be eutrophic due to increased phosphorus values. The increased deterioration of the lake was attributed to the high residence time of water.

Dar et al. (2020), worked on the major water bodies of Srinagar which are the source of sustenance to the local people. However, due to unsustainable use the degradation of these water bodies is taking place. Introduction of alien species and climate change are the major threats to these water bodies.

Dar and Srivastava (2021), worked on the water quality index of Dal Lake and found that most of the parameters have crossed the desired limit and as such not suitable for drinking purposes. Their study suggested that monitoring the quality of the lake water is needed for the conservation of the lake. Kumar et al. (2022), studied the importance of Dal Lake and the different services provided to the people. However, due to increasing population untreated sewage enter into the lake and change its chemical properties. It was observed that the dissolved oxygen content has decreased during the past years and a corresponding increase in the hardness of water.

2.3. HMs in Dal Lake

Dal Lake has been polluted by different factors among them the heavy metal pollution is also contributing to its water quality degredation. Baek and An (2010), argued that rural ecosystems are contaminated very less as compared to urban ecosystems. Extremely high chemical concentrations in artificial ecosystems are related with runoff from the urban surroundings, which include street dust that has been contaminated with HMs. Copper was shown to be the most readily extractable of the six HMs examined, followed by Nickel and Zinc. Boparai et al.2011; Lajayer et al., 2017; Bardiya-Bhurat et al., 2017), found that large portion of the land under cultivation have been polluted as a result of the continuous and excessive use of chemical fertilizers in agriculture fields for enhanced crop production. Although, many HMs are present in the environment naturally however, their values increase due to anthropogenic activities. When discharged into the environment, Hossain et al. (2012), discovered that they can either be in the form of free ions (such as Zn^{2+}), or linked with some organic molecules (such as Cu^{2+}).

Salem et al. (2014), observed that HMs have been observed in polluted wetlands, sediments, macrophytes, and other organisms, with levels varying from year to year. For aquatic environment monitoring and management, HMs in wetland water, sediment, and macrophytes must be researched geographically and temporally. According to Preetha and Kaladevi (2014), macrophytes are an important component of aquatic ecosystems because they can act as a heavy metal accumulator as well as a source of food for many aquatic species and to remove the pollutants.

Showqi et al. (2018), compared the number of pesticides in the agricultural run-off and effluents of SKIMS, and found its concentration was much higher at these locations as compared to the control site lake center. Further investigations revealed that most metals with high concentration are present in the water and sediment during the autumn.

Specifically, the findings indicated that continuous monitoring of these chemical species are required for the preservation of the lake's ecological state and that of its adjacent surroundings.

Many HMs are classified as biometals in plants because they are components of a variety of critical enzymes, making them needed for basic metabolic development. According to Shahid et al. (2016) & Ali et al. (2013), excessive quantaties of HMs in the plant and soil parts, on the other hand, generate toxicity symptoms as well as the dysfunctioning/inhibition of a variety of normal plant activities, including morphological and physiological processes. Ahmad (2016), studied the role of constructed wetlands in the phyto remediation process.

HMs have similar harmful effects on plants, according to Bardiya-Bhurat et al. (2017), they cause growth suppression, low biomass production, chlorosis, and disturbed water and mineral nutrient balance, all of which contribute to plant senescence. While some HMs, such as Zn, Mn, Cu, Ni, and Fe are required as micronutrients by animals and plants in minute amounts, others, such as Cd, Cr, Hg, and Pb, have no known physiological action and are exceedingly hazardous even at very low levels (Kar, 2008).

Lone and Shah (2019), observed that Kashmir Valley has a number of semi polluted lakes, including Manasbal, Dal, Anchar and Wular. In terms of hydrology, economical activities, and recreational opportunities, these lake systems are rich resources. The biodiversity and economic survival of the region are dependent on these lake environments. People who reside in the catchment areas benefit from the lakes because they provide potable water, watwer for tourism and the hydroelectrical activities carried out by the Govt. of J and K. Mehmood et al. (2019), studied the higher doses of HMs from some fish species growing in Kashmir Himalayas, which in turn magnify at the different trophic levels once they enter into the food chain**.**

Ramachandra et al. (2020), reported that due to unplanned development processes the surface run off from streets bring along heavy doses of metals into the water bodies there by contaminating them and the dwelling fauna and flora. Khan et al. (2020), Studied that macrophytes such as *Lemna minor* play an important role in the accumulation of HMs from waste waters and is involved in the purification process of water. Eid et al. (2020), studied the role of four dominant macrophytes in the phytoremediation of HMs and their role as pollution indicators in these water bodies. Qayoom et al. (2021), reported the heavy metal concentrations from sewage of Srinagar municipal limits after treatment from the sewage treatment plants which are located in the vicinity of Dal Lake, then it was evaluated on its capacity to create carcinogenic and non carcinogenic effects and the economic costs incurred. Bashir et al. (2021), reported the concentration of HMs from macrophytes, sediment and water components of Shallabug wetland and presented a consolidated account. Abdelaal et al. (2021), Studied the role of seven important members of macrophytes in the phytoremediation of selected HMs such as Lead, cadmium, zinc, iron and nickel from Nile, Egypt.

Bukhari and Lone (2013), worked on the heavy metal concentration of springs of Zabarwan mountains of Srinigar and the different stations of Dal Lake and found that the load of HMs to the Dal Lake is contributed by these springs present in the vicinity. During the study it was found that higher concentration of nitrate is found and may be alarming for the local population. Khan et al. (2013) studied the heavy metal concentration in the drinking water of Dal dwellers which gets polluted due to the direct inflow of sewage into the lake and is in eutrophic state.

Shafi et al. (2015), worked on the free-floating type macrophytes and their role in the purification of water by removing HMs from Dal Lake. It was concluded that *Azolla pinnata* plays an important role in the removal of HMs like lead, cadmium and copper therby playing a role in remediation process.

Bhat et al. (2017), worked on the nutrient status of Dal Lake and found that the nitrate and phosphate concentrations varied at the Shalimar Park and Dugg park during the summer and autumn season. The highest concentration of nutrients was found at the Shalimar ghat and next at the Ashie bag mainly due to the increasing population. Mukhtar and Bhat (2017), studied the limnological features of Brarinambal site of Dallake and found thst the water quality index has changed post 2014 floods. The examination of the different parameters of water such as permeability index and sodium absorption ratio show the waters are fit for the irrigation of fields and not for drinking. Mukhtar and Chisti (2018), studied the heavy metal load of Dal Lake waters. The lake waters were analyzed by by atomic absorption spectrophotometer. It was found that the heavy metal concentrations were below the limits. Hence the monitoring of the lake to taken care on regular basis. Wani et al. (2020), worked on the HMs of Dal Lake and found that the waters have toxic levels of certain metals like lead and cadmium which alter the physiological functions of the plants and effect the human health also, but some plants have the capacity to remove these HMs thereby playing role in remediation process. Shah et al. (2021), worked on the heavy metal concentration of sediments of Dal Lake and found that the there is moderate pollution of lead, nickel and copper from margins towards the center of the lake. They concluded that anthropogenic impact plays a role in altering the lake behavior.

2.4. Economic evaluation of the Dal Lake

The economic value of flora and fauna and cost benefit analysis linked with their deterioration are complicated, and they are rarely taken into consideration in economic analyses. In order to express the advantages that people get from ecosystems; the notion of ecosystem services may be utilized to explain these values. Leitch (1983), suggested that there should be an interdisciplinary cross talk so as to arrive at a common decision of providing a competitive economic value to the wetland services. This concept is frequently adopted to estimate benefits received from ecosystems. Barbier et al. (1997), observed that the goods and services obtained from the wetlands have to be given an important role while making the policy decisions on conservation and management, and it will just be unwise if we don't take into account the huge services provided by the wetlands in the form of direct benefit, indirect benefit and Hedonic pricing these findings were also seconded by Ramachandra et al. (2005). Turner et al. (2000), studied in detail the approaches for the management of wetlands.

They observed that the failures of the Govt. agencies lead to the further deterioration of wetland management policies, besides suggesting the integrated approaches for strengthening Govt. efforts on preservation of economically important wetlands. Verma et al. (2001), studied the importance of wetlands which acts as the transitional zones between aquatic and terrestrial places and play an important role by acting as sinks of pollutants and stabilizing of local climate and thus derive a tremendous economic importance by providing these services. Lambert (2003), observed that a price tag should be provided to each and every service provided by the wetlands which will help in effective management and derivation of economic benefits. However, if the market price is not available Willingness to pay approach should be used**.**

Pandey et al. (2004), studied the ecological and economic prospective of different Indian wetlands and classified them into different eco zones.

Maler et al. (2006), believed that wetland habitats are very productive natural ecosystems. The value of ecosystems is becoming more popular due to there significance for ecological balance. The benefit transfer approach may be used to forecast the value of additional wetland functions. This process needs just a little investment of time and resources. This research estimated financial gains achieved by preserving the beauty of lakes in China, taking into account the biodiversity conservation, water preservation, and economy generation.

Zuber (2007), worked on the economic evaluation of Mansar lake, Jammu and presented a detailed overview of the goods and services which are derived from the lake besides the benefits (direct and indirect) using Cost of Illness Approach, Cost of Water Abstraction and supplies thereof besides Hedonic Pricing Approach, Travel Cost Method and Contingent Valuation Method. This study was carried out by a respondent survey model seeking their opinion regarding the existence value of lake while using standard questionares. Mukherjee (2008), observed that wetlands provide important services in the form of water, electricity, and other ecological benefits such as vegetables all of these services contribute directly or indirectly to the economy of the state and the country. These observations were also approved by Verma et al., (2001).

Turner et al. (2009), presented a voluminous account of human perception of wetlands and relationships with them have evolved in tandem with changes in society's organization and scientific knowledge. In addition, they found that wetlands in many parts of the world have unique links with certain interest groups and human communities. Abubakar et al. (2011), studied the important groups of macrophytes in different wetlands of Kashmir and highlighted the importance of certain members such as *Trapa, Typha, Nulembo* which are used by the locals directly or indirectly for food, fodder besides for generation of economic benefits. Cui et al. (2012), reported the benefits of evaluation of wetland resources in the Dongting lake and discussed the models of protection of wetlands for their sustainable management.

Brander (2013), provided an in-depth analysis of three most important services provided by the wetlands in the agricultural outfield such as water supply, flood control and cycling of nutrients. Nandagiri (2015), argued that water ecosystems offer a broad variety of benefits and consumption opportunities for humans. However, these advantages are still generally overlooked in choices regarding the charges and its services among other things. Ecology may now be valued in terms of their entire financial value, which is a relatively new concept. The TCM and CVM was carried out using Open-Ended questions. A questionnaire was used to conduct a direct interview with 500 visitors to Pilikula lake, which resulted in the completion of data bank, which was then interpreted using Microsoft Excel and the SPSS Statistical software packages.

Emerton (2016), was of the opinion that Total Economic Value should be taken care of on priority while trying to categorise the wetlands. Under valuing of the different benefits such as goods and services by the wetlands leads to significant economic losses. Chaikumbung et al. (2016), published the first thorough synthesis of economic assessments of wetlands in poor nations, which they call the Chaikumbung Report. According to findings, these ecosystems provide innumerable services to mankind. The projected values of wetlands based on expressed preferences are lower than the projected values based on market pricing approaches. In general, MRA (meta regression analysis) is beneficial for determining the monetary gains of wetlands at policy locations in some under developed countries, according to the outcomes of the current study.

Muller et al. (2016), undertook a valuation of a lake ecology and an assessment of the possible costs of harm resulting from its deterioration. The strategy was used in the case of Lake Rotorua. It was observed that the ecological services given by this Lake were worth a large amount based on a variety of indicators and pricing methods. The worth of the ecosystem services was estimated to be between NZD 94 and 138 million per year. Reynaud and Lanzanova (2017), carried out meta-analysis regarding the economic services provided by lakes, which was conducted in 2008. A global data collection of about 700 observations across more than 100 research studies were used to create a comprehensive picture of these lakes and their present status. The meta-analysis investigates the interactions and synergies that exist between biological services. This analysis at the same time included both external geographical data and interactions across ecosystem services.

Lu et al. (2017), worked on the economically important vegetation types of China such as Lotus and their history of cultivation from the last three thousand years. Their study revealed that agricultural systems can have a variety of environmental impacts at different scales (spatial and temporal).

Srinivasan and Palani (2018), argued that lakes are important productive ecological units on the planet, and they are well-known around the world for conserving a diverse range of biodiversity patterns, while simultaneously providing a variety of commodities and services. Although various manmade activities have increased in recent years, they have had an impact on the overall biological processes of the lake ecosystem, as evidenced by an assessment of the lake. The mean wealth created by the ecosystems was around was 3041 INR /sq.km/day. Because of little rainfall and inadequate lake management, there is a limited supply of lake water availability, which has resulted in a drop in the number of fish fauna and pollution of the water. This economic loss as well as the degradation of water quality, indicates that it is necessary to implement environmental management measures in order to regain the advantages that have been lost.

Darby et al. (2021), described the economic worth and recreational usage of water and its deterioration impact on the national economy. It was accomplished via the use of data by survey method in conjunction with regression model to assess its value outside the market. The findings imply that the level of water in a rural lake has an impact on tourism as well as the economic worth of nature-based leisure activities. It also serves to emphasize the magnitude of the effect that management might expect from a decrease in visitor numbers as a result of a drawdown or drought. Shah and Islam (2021), observed that many recreational benefits are derived from the Kashmir wetlands such as boating, rafting and houseboat services besides some accessory services which once computed generated a huge amount of money there by acting as the special economic drivers.

The perusal of the review undertaken gives an idea that the Dal Lake in the union Territory of Jammu and Kahmir has a very high impact of increasing human population and the the large quantaties of fertilizers which enter into it because of surface runoff and change the chemical nature of the water body, and as a consequence there is a change in the dominance of macrophytes species which under most polluted conditions choke the oxygen content thereby leading to the death of the different animal species.The Dal Lake which houses the world famous lotus contributes greatly to the economy of the Union Territory by way of different products which are derived from the wetland and the prime attraction to the tourists there by contributing to the upliftment of the local population. In order to gain the information about the goods and services derived from the Dal Lake and the the tourists who visit the union territory of J&K because of it, two questionnaires (CVM and TCM) were developed and the responses were recorded from the participants.

Rather (2012), worked on the linkage between economy and environment in Dal Lake and observed that the lake provides different benefits, but the carrying capacity of the lake need not to be compromised and the misuse of resources need to be checked and the management of water bodies undertaken for the overall benefit of the society.Wani et al. (2013), worked on the natural resources derived from the Dal Lake and the primary among them were the water resources which are used for drinking and irrigation purposes and thus help in the uplifting of local economy by way of recreational and other aspects.

Mohsin (2016), worked on the economic upliftment of people by the Dal Lake and the impact it has created on the lives due to lock down when no economic activity took place in the Kashmir valley. The study stresses on the need to put up a road map for the people who directly make their living from Dal Lake by acting as tourist guides and selling day to day utilities in the lake banks. Wani et al. (2019), studied the economic potential of two water bodies Jehlum and Dal Lake and found the most of the people are involved in water related activities and drive their livelihood by Vegetable cultivation and boating and fishing activities with in the lake. Due to the increased tourist arrivals the Dal Lake has come under pressure and the measures for its conservation need to be taken. Shah and Islam (2021), worked on the economic aspects of the Dal Lake and computed the different services provided by it in the form of water extraction, vegetable cultivation and tourist arrivals, there by indicating that the lake has huge potential to restore the economic condition of the state. More research needed to be undertaken on the Dal Lake to find out the reasons of deterioration and suggesting some scientific measures so that the beauty of the lake can be cherished by the future generations as well.

CHAPTER 3

HYPOTHESIS

3.1. Hypothesis

Water bodies act as the dwelling place for a number of aquatic organisms and primary sinks of pollutants. Fifty percent of the global wetland wealth has shown a drastic reduction during the last ten decades (Mohammad et al., 2018). The dominant macrophytes and the floating gardens of the Dal contribute to the economy of the state, besides the world-famous houseboats and Shikaras add to the income generation of the stake holders. However, due to the increased human interference, the lake is facing an imminent threat of habitat loss and the dwelling floral and faunal species due to more rapid shift from oligotrophic to mesotrophic to eutrophic states. As a result of this, the chemical parameters of the water have changed which has affected its water quality such as DO, BOD and COD. This has affected the flora and fauna within the lake and has decreased its aesthetic appeal. The present study attempts to enquire (through survey) about the primary cause of anthropogenic threat, changing water quality parameters, identification of dominant macrophytic species and economic valuation of the Dal Lake (through survey) and the possible conservation measures for its sustainability. Objective 1: Evaluation of the impact of anthropogenic activities on the ecology of Dal Lake.

Alternate Hypothesis (H1): Anthropogenic activities exert a significant negative impact on the ecological health of Dal Lake, resulting in measurable deterioration of water quality, reduction in biodiversity, and disruption of ecological processes.

Null Hypothesis (H0): Anthropogenic activities do not exert a significant impact on the ecological health of Dal Lake, and any observed variations in water quality, biodiversity, and ecological processes are attributable to natural environmental fluctuations. We reject the null hypothesis and accept the alternate hypothesis

Objective 2: Identification and classification of different macrophytes growing in the Dal Lake.

Alternate Hypothesis (H1): The macrophyte community in Dal Lake exhibits significant diversity, comprising distinct species that demonstrate specific adaptations to the varying physico-chemical conditions within the lake. We reject the null hypothesis and accept the alternate hypothesis.

Null Hypothesis (H0): The macrophyte community in Dal Lake does not exhibit significant diversity, and there are no distinct species with specific adaptations to the varying physico-chemical conditions within the lake. We reject the null hypothesis and accept the alternate hypothesis.

Objective 3: Evaluation of the physico-chemical properties of water in Dal Lake.

Alternate Hypothesis (H1): The physico-chemical properties of Dal Lake's water, including parameters such as pH, dissolved oxygen, nutrient concentrations, and turbidity, are significantly influenced by anthropogenic activities.

Null Hypothesis (H0): The physico-chemical properties of Dal Lake's water are not significantly influenced by anthropogenic activities, and any observed changes in these parameters are due to natural environmental variability. We reject the null hypothesis and accept the alternate hypothesis.

Objective 4: Economic evaluation of the Dal Lake.

Alternate Hypothesis (H1): The ecological health of Dal Lake significantly influences its economic value, with ecological degradation due to anthropogenic activities adversely affecting its economic contribution. Null Hypothesis (H_0): The ecological health of Dal Lake does not significantly influence its economic value, and any variations in economic contribution are independent of ecological conditions. We reject the null hypothesis and accept the alternate hypothesis.

CHAPTER 4

Aims and Objectives

Aims and objectives

The aim of the current study was to find out the reasons of deteriorating water quality and the decline in the production of some economically important plant species and to suggest the recommendations for the conservation of Dal Lake. The objectives of the present study were

- Evaluation of the impact of anthropogenic activities on the ecology of Dal Lake.
- Identification and classification of different macrophytes growing in the Dal Lake.
- Evaluation of the physico chemical properties of water in Dal Lake.
- Economic evaluation of the Dal Lake.

Chapter 5

Methodology

5.1 Estimation of anthropogenic threat on the lake

A survey was done around the Dal Lake to determine the factors affecting the ecology and biotic status of the lake, and to assess the influence of anthropogenic activity in the catchment. For this survey, a five-point Likert scale was utilized, and participants were asked a number of related questions about the pollution and deterioration of the Dal Lake's ecological status (McLeod, 2019). Chemical examination of water in different seasons during the study period was done to calculate the change in water characteristics as a result of human imposed pressure. The study sites of the Dal Lake are shown below in the (Fig. 5).The four sites were chosen namely (A) Hazratbal, (B) Habbak, (C) Laam and (D) Brarinambal for water sampling and to check the anthropogenic influence in terms of water quality parmeters and heavy metal content.These four sites were chosen as there is greater habitation in the vicinity at these sites and also tourist foot fall which contribute to water pollution of Dal Lake.

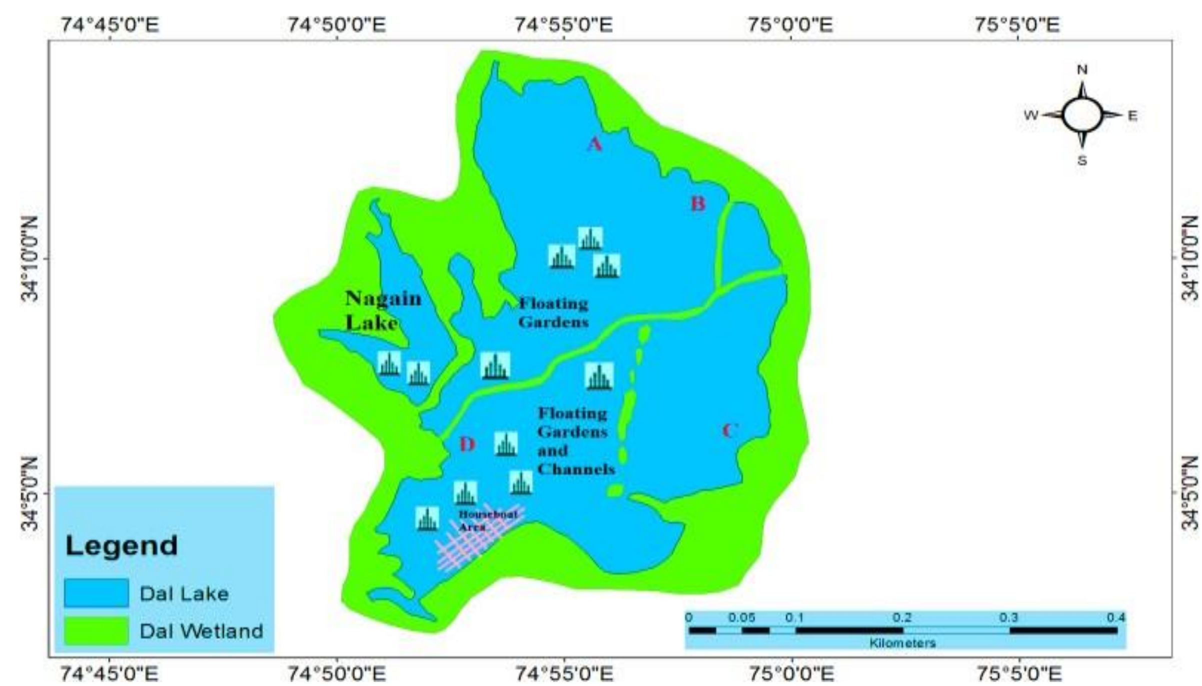
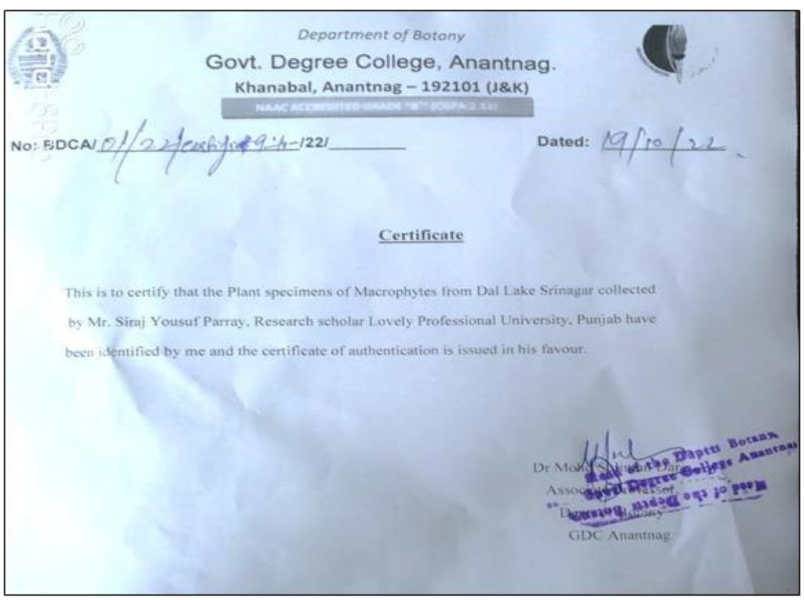


Fig.5: Map of Dal Lake study sites **(A)** Hazratbal, **(B)** Habbak, **(C)** Laam, and **(D)** Brarinambal.

5.2. Identification and classification of macrophytes.

For identification and classification of macrophytes species growing in the Dal Lake the study site was divided into four sampling sites namely Hazratbal, Habbak, Laam and Brarinambal. The dominant macrophytic plant species were then collected and identified at Government Degree College (GDC) Anantnag, Kashmir and the herbarium of these species was prepared. Random Quadrant method was used for determining different community characteristics (Misra,1968; Shanon-Weiner, 1949).

Diversity index is the mathematical measure of the species diversity, the higher the indices values higher is the diversity in a given area. They are generally dependent upon species richness (number of species present) and abundance (number of individuals/ species). According to Shannon Index all the species present in a sample are sampled randomly. Here p is the proportion (n/N) of individuals of a single species divided by the total number of individuals (N), like wise in Simpson index. The values of Shannon Index range from 1.5-3.5. Simpson's index takes into account the dominant species types present in that area and their values range from zero to one.



Department of Botany

Govt. Degree College, Anantnag.

Khanabal, Anantnag – 192101 (J&K)

No: BDCA/ 01/22/ [illegible] /22/ Dated: 19/10/22

Certificate

This is to certify that the Plant specimens of Macrophytes from Dal Lake Srinagar collected by Mr. Siraj Yousuf Parray, Research scholar Lovely Professional University, Punjab have been identified by me and the certificate of authentication is issued in his favour.

Dr Mohd [illegible] Dar

Associate Professor

Department of Botany

GDC Anantnag

1. $Frequency = \frac{Total\ number\ of\ quadrats\ in\ which\ the\ species\ occurred}{Total\ number\ of\ quadrats\ laid} \times 100$

2. $Relative\ frequency = \frac{Frequency\ of\ species}{Frequency\ of\ all\ species} \times 100$

3. $Density = \frac{Total\ number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ quadrats\ laid}$

4. $Relative\ density = \frac{Number\ of\ individuals\ of\ a\ species}{Number\ of\ individuals\ of\ all\ species} \times 100$

5. $Abundance = \frac{Total\ number\ of\ individuals\ of\ species}{Total\ number\ of\ quadrats\ in\ which\ species\ occurred}$

6. $Relative\ Abundance = \frac{Total\ number\ of\ species\ A}{Total\ number\ of\ individuals\ of\ all\ species\ recorded} \times 100$

7. $Shannon\ Wiener\ Index = \sum i\ (\frac{ni}{N}.\ log2\ \frac{ni}{N})$

8. $Simpson's\ Index = \frac{\sum_i n_i(n_i - 1)}{(N-1)}$

5.3. Determination of physico chemical characteristics of water

For the analysis of water, the samples were taken from from four different stations of the Dal Lake viz, Hazratbal, Habbak, Laam and Brarinambal shown in the Fig 1. The different parameters observed are here under:

(i) Based on visual observations, weather conditions were classified as Bright, Bright Sunny, Cloudy, Cloudy and Rainy, and Rainy.

(ii) The temperature of the atmosphere was monitored with a mercury bulb thermometer, which was kept out of direct sunlight (Welch, 1952). The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

(iii) Water temperature: The water temperature was measured using a mercury centigrade thermometer with a 0.1℃ graduation and a range of up to 110℃. The thermometer was dipped vertically into the water to achieve this (Welch, 1952). The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

(iv) Color: Color was assessed visually by comparing samples with known amounts of coloured solution (using platinum – cobalt – comparator) following Kudesia (1980).

(v) A Secchi disc with a diameter of 20 cm was used to measure the transparency of the water. (Welch, 1952).

$$T = x + y/2$$

Where T = Transparency in cms

X = depth at which the disc becomes invisible

Y = depth at which the disc reappeared while pulling the rope upward.

(vi) Depth A straight rod calibrated in centimeters was used to measure depth of water.

B) Chemical parameters

i) pH A portable field pH meter (Sartorious, USA) was used to determine the pH of water. It measures the hydrogen ion concentration in water. The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

ii) Free Carbon Dioxide: It was calculated by using titrimetric method (APHA, 23rd edition, 2017). The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

iii) Carbonates and bicarbonates: It was calculated by titrating the sample with a strong acid (H_2SO_4 or HCl) first at pH 8.3 by using phenolphthalein as an indicator and then at pH 4.2 and 5.4 with methyl orange as an indicator. They are called as phenolphthalein alkalinity and total alkalinity respectively. The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

Procedure

1. 100 mL of sample was taken in a conical flask and two drops of phenolphthalein indicator were added.

2. If the solution remains colour less, PA= 0, in that case alkalinity can be calculated by following step 4.

3. If the addition of phenolphthalein changes the colour to pink, then titrate it with 0.1 N HCl till the colour disappears. This alkalinity is called phenolphthalein alkalinity.

4. Add 2-3 drops of methyl orange and continue the titration until the yellow colour changes to pink at the end point, this is called total alkalinity.

Calculation

$$\text{PA as CaCo}_3\ \text{mg/L} = \frac{(\text{A} \times \text{Normality})\ \text{of HCl} \times 1000 \times 50}{\text{mL of sample}}$$

$$\text{TA as CaCo}_3\ \text{mg/L} = \frac{(\text{B} \times \text{Normality})\ \text{of HCl} \times 1000 \times 50}{\text{mL of sample}}$$

Where A = mL of HCl used with only phenolphthalein.

And B = mL of total HCl used with phenolphthalein and methyl orange.

iv) Dissolved Oxygen (DO): It was calculated b**y** Winkler's method.

Manganous sulphate reacts with alkali (NaOH or KOH) and forms manganous hydroxide which indicates the presence of oxygen. The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

Procedure

1. The sample was taken in a BOD bottle of volume (100-300 mL), cap the bottle properly without any air bubbles in it.
2. 1 mL each of $MnSO_4$ and alkaline potassium iodide was added to the solution, a precipitate appears.
3. Then stopper was put and shake well the contents, the bottle was kept as such to settle down the precipitate.
4. 1.2 mL of concentrated sulphuric acid was added, shake well to dissolve the precipitate.
5. Remove (50-100 mL) in a conical flask for titration. There should be no bubbling to avoid mixing of oxygen.
6. Then the contents were titrated within one hour of the dissolution of the precipitate against sodium thiosulphate and starch as indicator. The initial dark blue colour changes to colourless at the end.

Calculation:

$$\text{Dissolved oxygen mg/L} = \frac{(\text{mL} \times \text{N}) \text{ of titrant } 8 \times 1000}{\text{V2} - \text{V3}}$$

V2= Volume of the part of the contents titrated

V3= volume of $MnSO_4$ and potassium iodide added.

vi) Biological oxygen Demand (BOD)

Principle

It is the amount of oxygen required to stabilize the degradable organic matter under aerobic conditions. It involves the measurement of oxygen concentration before and after incubation for five consecutive days at 20℃ (APHA, 2017). The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

Procedure

1. Dilution water was prepared in a container by bubbling compressed air for 30minutes.
2. To the dilution water 1 mL of phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride each was added and then mixed properly.
3. Then neutralize the sample to a 7 pH by using 1 N H_2SO_4 or NaOH.
4. As the dissolved oxygen gets exhausted it is imperative to prepare a suitable dilution according to the expected BOD range.
5. Then dilution was made in a bucket and thoroughly mixed the ingredients and fill the two BOD bottles.
6. Instantly determine the dissolved oxygen content of one container and incubate the second bottle at 20℃ for five days.
7. After five days, determine the dissolved oxygen content of the incubated bottle.
8. Other two BOD bottles were taken to determine the dissolved oxygen in the first bottle immediately and DO in the second bottle after five days of incubation.

Calculation

$$\text{Biological Oxygen Demand mg/L} = (D0 - D5) \times \text{dilution factor.}$$

Where DO = Initial dissolved oxygen of the sample.

D_5 = Dissolved oxygen after five days.

Chemical oxygen demand (COD)

It is the measure of oxygen consumed when the oxidizable organic matter is oxidized by oxidizing agents for example $K_2Cr_2O_7$ and H_2SO_4.The sample was refluxed with $K_2Cr_2O_7$ and H_2SO_4 to neutralize the effect of chlorides in presence of mercuric sulphate. The amount of potassium dichromate used is proportional to the oxidizable organic matter in the sample (APHA, 2017). The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

Procedure

1. 20 mL of water sample in a 200-500 mL flask was taken.
2. 10 mL of 0.25 normal $K_2Cr_2O_7$ solution was added.
3. Small amount of $HgSO_4$ and Ag_2SO_4 was added. For higher chloride content $HgSO_4$ is added to the ratio of 10:1, to the chlorides.
4. After this 30 mL of H_2SO_4 was added.
5. Reflux for two hours, remove the flasks and add distilled water and make the final volume 140 mL.
6. Mix properly and titrate with 0.1 normal ferrous ammonium sulphate after the addition of 2-3 drops of ferroin indicator.
7. At the same time run a blank with distilled water with the same chemical quantity.

Calculation

$$\text{Chemical Oxygen Demand, mg/L} = \frac{(\text{b} - \text{a}) \times \text{ N of ferrous ammonium sulphate } \times 1000 \times 8}{\text{mL of sample}}$$

Where a = ml of titrant with sample

b = ml of titrant with blank.

vii) **Chlorides**

Principle: Combination of silver nitrate with chloride forms soluble white precipitate of silver chloride. After the precipitation of chloride free silver ions react with chromate forming reddish brown silver chromate (NEERI, 1986; APHA, 2017). The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

Procedure

1. 50 mL of sample in a flask were taken and 2mL of K_2CrO_4 was poured in to it.
2. Titrate the solution with 0.02 N $AgNO_3$ till the red colour appears.

Calculation

$$\text{Chloride mg/L} = \frac{(\text{mL} \times \text{N}) \text{ of } AgNO_3 \times 1000 \times 35.3}{\text{mL of sample}}$$

Calcium

Procedure

1. 50 mL sample was taken in a flask.
2. Then 2 mL of sodium hydroxide was added to the sample.
3. Addition of 100- 200 mg of murexide indicator develops pink colour.
4. Then titrate against EDTA till the pink colour changes to purple, compare this purple colour with the distilled water blank.

   Calculation

$$\text{Calcium mg/L} = \frac{\text{X} \times 400.8}{\text{mL of sample}}$$

Where × = volume of EDTA used.

Magnesium

The amount of magnesium was calculated by subtracting the calcium value from total calcium and magnesium. The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

Procedure

1. Calculate the amount of EDTA used for the determination of calcium.
2. Find out also the volume of EDTA used in calcium and magnesium hardness.

Calculation

$$\text{Magnesium (mg/L)} = \frac{(\text{y} - \text{x}) \times 400.8}{\text{Volume of sample} \times 1.645}$$

Where y= EDTA used in determination of hardness.

And × = EDTA used in the determination of calcium (APHA, 2017).

ix) Total hardness: Was determined by using the following formula given by (Adoni, 1985):

$$\text{Total Hardness as mg/L CaCO3} = \frac{\text{ml of titrant used for EBT indicator} \quad \text{X 1000}}{\text{Vol.of sample taken}}$$

x) Platinum Electrode Cell was used to determine conductivity (APHA, 2017).

xi) TDS (Total dissolved salts)

TDS is estimated as the residue left after the evaporation of filtered sample. The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

Procedure

1. An evaporating dish was taken and ignited at 50^0Cin a muffle furnace for one hour.
2. Then after filter the sample through glass fiber filter paper.
3. Evaporate 100 ml of sample at a temperature of 98^0C.
4. At last residue was heated at 100-105°C in an oven for some one hour and final weight was taken.

Calculation

$$\text{TDS mg/L} = \frac{\text{A} - \text{B} \times 1000}{\text{V}}$$

Where A= Final weight of the dish in grams

B= Initial weight of the dish in grams

And V= Volume of the sample in mL.

xii) Turbidimetric Method was used to estimate sulphates (APHA, 2017; NEERI, 1986; Chopra and Kanwar, 1991).

xiii) Sodium and potassium Flame photometer was used for the estimation of both Sodium and potassium (NEERI, 1986; APHA, 2017). The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

a) Sodium

Procedure

1. Pretreatment of the polluted samples
2. 250 mL flask was taken and 25 mL of conc. nitric acid was added to acidify it, and was heated until the acid got evaporated. The unoxidized organic matter which is indicated by brown fumes to which more conc. nitric acid and little quantity of hydrogen peroxide was added. The residue is dissolved in Hcl and warm distilled water.
3. Sample was filtered through filter paper to remove any suspended matter.
4. Flame photometer was used to find out the concentration.

Calculation

$$\text{Sodium mg/L} = (\text{ mg/L in diluted aliquot}) \times \text{dilution factor}$$

b) Potassium

Procedure

Same procedure was used for the determination of potassium as for sodium. The water samples were collected in the mid of every month from December 2020 to November 2021 and the average values were calculated on seasonal basis such as winter spring summer and autumn.

Calculation

$$\text{Potassium mg/L} = (\text{ mg/L in diluted aliquot}) \times \text{dilution factor}$$

xvi) Fluoride Electrode method was used for the estimation of fluoride (APHA, 2017)

xvii) Iron

Procedure

1. 50 mL of sample was taken in a 150 mL flask.
2. 2mL of hydrochloric acid and 1 mL of hydroxylamine was added.
3. Boil the contents to dissolve all the iron.
4. After cooling 10 mL of ammonium acetate and 2 mL of phenanthroline was added until orange red colour appeard.
5. Make the final volume 100 mL and after 10 minutes the reading was observed on spectrophotometer at 510nm.
6. Prepare a standard curve of 1 – 4 mg/L of iron by using different dilutions of standard iron solution.
7. Lastly the concentration of iron was from the standard curve.

xviii) Nitrate nitrogen

Nitrate nitrogen was determined by phenol disulphonic acid method (APHA, 2017). In a 200 ml flask, 100 ml of water sample was evaporated to dryness and then 2 ml of phenol disulphonic acid was added to the residue and left for 10 minutes. After that, 80 mL distilled water and 2 mL of magnesium sulphate were added, followed by a drop-by-drop addition of sodium hydroxide until the formation of magnesium hydroxide precipitate, which was removed by using Whatman filter paper No.1 and the volume was increased to 100 mL. The resulting yellow colour of the sample was tested for absorbance at 410nm against a reagent blank made in the same way.

xix) Ammonical nitrogen

For the estimation of ammonical nitrogen 8 ml sodium phenate, 4 ml hypochlorite, and two mL manganous sulfate were added to a 20 ml water sample contained in a 50 ml graduation flask, after shaking, and the volume was brought up to 50 ml with ammonium free distilled water. The flask was tightly sealed and heated in a water bath at 70°C for 40 minutes and then cooled for 10 minutes before measuring absorbance at 625 nm using a Systronics spectrophotometer (APHA, 2017).

xx) Orthophosphate

Orthophosphate in water samples was evaluated the same day, within 3 to 4 hours of collection, using the stannous chloride reduced phospho-molybdate method (APHA, 2017). 1 mL ammonium molybdate and 2-3 drops stannous chloride were added to a 25mL water sample, and the resulting blue colour was measured at 690 nm on a spectrophotometer. The collection of samples for analysis from the four study sites was taken and graphic representation is shown below in the (Fig. 6).

5.3.1. HMs estimation

Procedure

1. All samples are weighed.

2. Acid digest the samples using Aqua Regia (a small amount of hydrogen peroxide is added in case of samples having high organic content).

3. The digested samples are filtered through micro filters.

4. Calibration curves are made using standard solutions as per the element to be screened.

5. Before starting the analysis the instrument is tuned for its standard operation using a tuning solution.

6. After standardizing the parameters during tuning, the instrument is ready for elemental analysis of the samples.

Fig. 6. Sampling sites in Dal Lake: **(A)** Hazratbal; **(B)** Habbak; **(C)** Laam and **(D)** Brarinambal.

5.4. Economic evaluation of the Dal Lake

The economic importance of an environmental system was estimated by adding the monetary values to all the services (Freeman, 1993). It involves attributing a price value to the benefits and other services derived from the ecosystem. Money is used as a measuring rod because people express their preferences in monetary units to indicate gains and losses in the economic sector. The revenues or benefits of environmental resources have a greater impact on the quality life of people. A complete economic valuation involves a number of values, the majority of which are classified as use or non-use. Use values encompass direct and indirect values in addition to existence values (Pearce, 1995).

The following is the methodology which was used for the valuation of Dal Lake.

5.4.1. "Direct Valuation"

The lake provides several direct benefits, such as drinking water and recreational activities such as boating and water sports. The monetary value of the primary benefits, as well as the money earned through these activities, has been calculated based on the number of people who live there and their average annual income. Those covered included boatmen, tea stalls, lakefront merchants, food and cold drink dealers, dhaba wallahs, fruit sellers, and others. Apart from that, the cost of providing water to the population has been considered, as well as the water tax imposed on them.

In addition, the revenue generated by hotels, houseboats, and shikara riders has been taken into consideration. This information was collected from secondary sources besides interaction with the direct stakeholders

5.4.2. "Cost of Illness Approach"

Water borne diseases are becoming more widespread among people that rely on lake water as a result of anthropogenic influences such as siltation followed by sedimentation owing to deforestation in the catchment area, human and cattle fecal matter, sewage, polythene, encroachment, and other reasons. Data on the number of instances of water-borne infections reported in the previous two years was acquired from government dispensaries and health centers. On these cases, the average expenditure and the total amount spent on average was calculated. Wages lost while recovering from illness have also been taken into account. Furthermore, in order to protect one self from these water-borne infections, people take several preventative precautions and their readiness to pay for the clean water.

5.4.3. Travel Cost Method

This method uses travel charges as a means for accessing outdoor recreational sites, is the oldest method of valuation process. This is a market-based method in which demand is determined by correlating the number of visits and the cost incurred per visit. Visitors who reside more away from the site pay a larger transportation expense than the ones who live closer to the site. It is also used to figure out the benefits of leisure resources such as parks and gardens (Goodstein, 1995). The purpose of this method is to find out how much individuals pay to get access to a particular resource. In this scenario, the cost of visiting the Dal Lake could be utilized to reveal the tourists' preferences for the environmental services supplied by it. Apart from actual transportation costs, travel costs may also include boarding and accommodation fees paid at a guest house, as well as the cost of travel and the time spent on the journey.

5.4.4. Contingent Valuation Method

In early 1960, Robert K. Davis invented the phrase "Contingent Valuation Method" after using surveys to measure the benefits of outdoor recreational activity. According to Davis (1963), this technique puts the interviewer in the commonding position of a seller looking for the greatest price for the services being provided. The CVM allows people to learn about their preferences for public goods and how much they would pay for specific improvements. As a result, the method aims to elicit their monetary willingness to pay (WTP) (Mitchell and Carson, 1989). The CVM is essentially a public poll in which participants are asked a series of questions. A detailed explanation of the things being appraised, as well as the hypothetical scenario which is provided to the respondents

1. Questions that elicit the willingness of the respondents to make payment for the valued products
2. Questions concerning the characteristics of respondents (age, income, occupation, education level, etc.) their preferences for the things being rated, and their use of the goods.

The results are then generalized to populations from which the respondents were sampled with a known margin of error, with the results being used to estimate benefits. Furthermore, many people have noticed that the information in the CVM questionnaire has a considerable impact on the respondent's value statements (Fischoff and Furby, 1988). According to Munasinghe and Mc Neely (1994), this technique becomes more effective when respondents are more aware of environmental goods and services. CVM was used in this study to assess the recreational benefits that the lake delivers to inhabitants and visitors in and around Srinagar. A thorough questionnaire was employed in this study to extract people's Willingness to Pay (WTP) for good recreational and aesthetic beauty of the lake. Each respondent/household was asked to declare how much they would be prepared to pay in order to enjoy additional benefits from the lake, as well as how much they would be willing to contribute as a tax, with all collections going toward the maintenance and improvement of recreational amenities.

5.4.5. Hedonic Pricing Method: If relevant market data for valuing environmental resources is unavailable, statistical and econometric methodologies are used to examine the series of indirect benefits thus helping in implicit valuation (Munasinghe and Mc Neely, 1994). In areas where land markets are very competitive, it is possible to break down the prices of real estate into smaller components due to various features such as closeness to schools, shops, and parks (Cropper and Oates, 1992). As a result, rising prices in the cleaner environments compels people to pay more and obtain good services (Munasinghe and Mc Neely, 1994).

Statistical Analysis: All the experiments were done in triplicates and the analysis was performed by using SPSS (Statistical Software), Minitab and R core for analysis of limnological data.

CHAPTER 6

Results and Discussions

6.1. Impact of increasing population and the use of fertilizers and pesticides on the Dal Lake.

A survey was conducted to find out the impact of human activities on the ecology of the Dal Lake. It was observed that the exponential increase in human population and the illegal settlement within the water body is causing unsustainable exploitation of wetland resources and is a potential threat to the carrying capacity and very survival of the wetland (Table 2.5 and 6). During the present study a large population present in almost thirty-five localities are dependent on the Dal Lake and pose different types of pollution such as algal blooms and eutrophication (Parray et al., 2021)

Table 2. Population survey in the catchment of Dal Lake (Population survey 2011).

S.No.	Name of the locality	Households	Population
1	Dalgate	3245	21231
2	Lalchowk	2028	13205
3	Buddal	2585	16435
4	Lokutdal	3785	22345
5	Zindshah shab	2215	14536
6	Jogilankar	3824	24846
7	Barbarshah	3192	19852
8	Bana mohalla	2565	17698
9	Khanyar	3245	20428
10	Khajabazar	2995	19897
11	Makdoom shab	3345	20232
12	Hazratbal	3496	21341
13	Tailbal	2848	18573
14	Ahmadnagar	4987	32889
15	Soura	1847	12985

16	Buchpora	3786	23752
17	Zonimar	2543	16878
18	Palpora	3698	27433
19	Aali kadal	1445	9535
20	Qamarwari	1427	9833
21	Chattabal	2768	18498
22	Bemina	4757	30945
23	Parimpora	2685	18749
24	Zainakoot	3245	22832
25	Maloora	3384	23243
26	Lawaypora	1765	13638
27	Batamaloo	2568	18322
28	Rajbagh	1795	11826
29	Jawhar nagar	2633	16328
30	Mahjoor nagar	4308	27348
31	Natipora	2545	15997
32	Nishat	3395	24873
33	Harwan	4978	31479
34	Safakadal	3145	21322
35	Saidakadal	1732	11827

Table 3. Land cover pattern in the catchment of Dal Lake (LAWDA, Srinagar).

S.No.	Category	Area\Km^2 (2000)	Area\Km^2 (2020)
1	Agriculture	28.84	23.98
2	Water body	18.50	15.78
3	Orchards	6.36	8.12
4	Plantation	15.13	13.98
5	Settlement	16.43	20.55
6	Meadows	9.70	8.56
7	Barren	12.60	10.03
8	Pasture	18.23	16.48
9	Wet plantation	4.47	5.60
10	Forest	110.5	89.70
11	Rakh	4.80	3.52
12	Floating garden	8.76	7.60

Table 4 Land cover pattern (change) in the catchment of Dal Lake (Rather and Dar, 2020).

Category	Area in Hectares (1981)	Area in Hectares (2020)	Change in Hectares
Water body	1533.0	1304.5	-228.50
Agriculture	36.50	753.00	716.50
Marshy area	867.0	310.0	-557.0
Built up	5.0	54.0	49.0
Plantations	8.5	28.5	17.0
Total built up	5.0	54.0	+49.0
Total non built up	2445.0	2396.0	-49.0

The study of catchment of the water body under various land use patterns reveal that there is a large area of land under forest cover, followed by agricultural land (Table 2,3,4). The change in land area from 1981 to 2020 is shown in Table 3, and the results show that the water cover area has decreased from 1533 hectares to 1304.5 hectares in 2020 (Rather and Dar, 2020). The intensive agricultural activities carried out in the catchment, as well as the Hangi activity in the floating gardens, cause heavy stress on the water body and a consequent shift in dominant macrophytes to emergent vegetation types and algal blooms. (Fazal and Amin 2012). The weed-covered area inside the lake where water-related operations such as the extraction of aquatic foods are carried out comes in the sub category of marshy area. In 1981, this land use category covered 862.5 ha, but by 2011, it had shrunk to 315 ha, a loss of 547.5 hectares (Amin et al., 2014). The people, and the Jal Shakti Dept. of the union territory of J & K, drain the waters from the lake for consumption, after treatment. During the current study it was calculated that 5.6 million gallons of water are extracted from Dal Lake per day thereby causing drastic water changes in the already water starved lake (Chief Engineer, PHE, Srinagar). These hydrological fluctuations, combined with a high rate of sedimentation have resulted in the fragmentation of lake habitat into marshland, aquatic vegetation zone and willow plantation, affecting floral and faunal diversity and distribution as well as the macrophytic community structure of this water body (Khan, 2000). Following rice farming, vegetable production is the most important agro-horticultural activity, consuming a large number of fertilizers and pesticides, which are eventually leached into the water body, increasing its nutrient content (Mushtaq et al., 2013) (Table 4), leading to eutrophication and accompanying algal blooms (Parray and Koul, 2021).

Table 5. Characteristics of different Basins of Dal Lake.

Basin Characteristic	Hazratbal	Habbak	Laam	Brarinambal
Length (Km)	3.4	1.8	2.3	2.6
Depth (mtrs)	2.9	2.7	3.2	1.8
Mean depth	2.6	2.4	2.9	1.6
Transparency	0.93	1.64	0.94	0.43

The different basin characters of the Dal Lake are provided in the (Table 5) where in the length of the basin, depth and water transparency are provided and the perusal of the table reveals that Hazratbal is the longest basin in terms of length and the Habbak has highest transparency and Brarinambal has lowest transparency (Mushtaq et al., 2013).

Table 6. Socio economic details of Dal Lake (LAWDA, Srinagar).

S. No.	Description	Details/number
1	Total number of structures	2532
2	Total structures from Ashai bag to Saida kadal	631
3	Total land of Dal Lake	49432 kanals
4	Number of house holds	6415
5	Number of extended families (living in same house but not sharing a chula)	4141
6	Number of males	18425
7	Number of female heads	506
8	Total number of shops inside Dal Lake	80
9	Sheds	189
10	Hotels and guest houses	5
11	Total number of houseboats	945

The different socio-economic details of the Dal Lake are given in the (Table 6) indicating total land area of the lake which is around 49432 kanals (LAWDA), the number of households including hotels and guest houses and the number of houseboats which are acting as the sources of pollution to the lake.

Table 7. Name of the hamlets within the Dal Lake (LAWDA, Srinagar).

S. No.	Hamlet	Population
1	Kabutarkhana	92
2	Batapora	182
3	Avren	78
4	Jala mohalla	52
5	Meena bazaar	35
6	Floating market	110
7	Golden lake	325
8	Voont kadal	21
9	Naidyar	1560
10	Bakhari mohalla	125
11	Baba mohalla	45
12	Meer mohalla	345
13	Laid mohalla	95
14	Goor mohalla	62
15	Batapora (C)	297
16	Choku mohalla	185
17	Bara mohalla	225
18	Dar mohalla	145
19	Lone mohalla	123

The small hamlets which are present in the Dal Lake obtain their livelihood from the Dal Lake by selling different vegetables or riding shikaras, (Table 7) but are causing the lake to degrade at a greater pace by way of different wastes released into the lake therby increasing the pollution rate of this important habitat (Pandit and Qadri, 1990).

Table 8. Load of fertilizers and pesticides in the floating gardens of Dal Lake.

S.No.	Hamlet	Area of floating garden in kanals	Fertilizer (Kg)	Pesticide (Kg)
1	Kabutarkhana	7.50	82.50	7.50
2	Batapora	12.00	132.00	12.00
3	Avren	3.00	33.00	3.00
4	Jala mohalla	4.00	44.00	4.00
5	Meena bazaar	2.50	27.50	2.50
6	Floating market	12.50	137.50	12.50
7	Golden lake	13.00	143.00	13.00
8	Voont kadal	2.00	22.00	2.00
9	Naidyar	25.00	275.00	25.00
10	Bakhari mohalla	7.50	82.50	7.50
11	Baba mohalla	2.50	27.50	2.50
12	Meer mohalla	18.00	198.00	18.00
13	Laid mohalla	6.00	66.00	6.00
14	Goor mohalla	4.00	44.00	4.00
15	Batapora (C)	16.00	176.00	16.00
16	Choku mohalla	12.50	137.50	12.50
17	Bara mohalla	17.00	187.00	17.00
18	Dar mohalla	7.50	82.50	7.50
19	Lone mohalla	6.00	66.00	6.00
	Total	**178.50**	**1963.50**	**178.50**

Urea (1.1/kg), DAP (6.5/KG), MOP (3.4/KG)

The increasing population count in the vicinity of the Dal Lake contributes to the higher doses of nutrients mainly nitrogen and phosphorus. During the study period an estimated fertilizer input of 1963.50 kilograms (Urea, DAP, MOP) in one season and pesticides of about 178.50 kilograms were used in the water body (Table 8), this was also observed by (Ishaq and Koul, 1990) in the Dal Lake. The higher quantities of fertilizers and pesticides used in the vegetable gardens of the Dal Lake and in the catchment of the water body are involved in changing the chemical equilibrium of the water body and a consequent shift in the ecological parameters. In addition to the increase in nutrient content, significant amounts of solid waste, both biodegradable and non-degradable, make their way into the water body, leading the water body to gradually fill at a greater pace. Thematic information on the types of features existing on the earth's surface are covered under land cover patterns (Dar and Romshoo, 2008). Although change in land use/land cover patterns is a natural occurrence that results from the intricate interaction of numerous environmental elements, it is frequently triggered and exacerbated by increased human activity, endangering the lake's very well-being and reducing its health (Kiage et al., 2007; Rather and Dar, 2020).

The siltation that occurs in lakes and wetlands, particularly during floods, is a natural phenomenon. In the last 30 years significant changes in land use pattern have been observed, with the urban area growing from 2,410 hectares in 1981 to 6,224 hectares in 2011, a 158 percent increase (Fazal and Amin, 2011). More than 60% of Srinagar's water bodies have been destroyed over the previous century, affecting not just the micro climate of the area but also exposing it to the possibility of flooding. These changes have engulfed the city's agricultural and forest land, as well as its water bodies. Effective coordination between inter governmental agencies for planning, monitoring, and assessment is needed for the active participation of local people in the development and maintenance of the watershed structures (Khare, 1989). The floating gardens, which are made up of the light weight of a network of roots and rhizomes, rise and fall in response to the fluctuation of the water level underneath them. Variations in climate or physical changes within the catchment could be contributing to the apparent reduction in summer water table levels. Despite the fact that both reasons are likely, the latter is the most important. The Jalshakti department's pumping stations, which lift water for drinking purposes to the local people after treatment, cause a drastic alteration in the Lake's hydrochemistry and may contribute to increased acidity (Gowing, 1977; Rather and Dar, 2020).

Table 9. Waste producing units in the catchment of Dal Lake (Srinagar Muncipality).

Category	Source	Type of waste
Household	Family apartments and residential quarters	Food waste, rubbish, detergents
Business establishments	Schools, Colleges, Universities, Nursing homes, Hospitals and utility stores	Food waste, industrial waste and toxic products
Open areas	Streets, Parks, Recreational spots, Boating and Musical events	Litter and other wastes
Waste production on daily basis	450 metric tons	100 ton of waste produce 30% compost

According to the SMC Srinagar, 100 tons of wastes are produced per day in the Srinagar municipal limits which somehow contribute to the ecological deterioration of the water body which is in the heart of the city (Table 9). These wastes are in the form of food wastes, detergents, industrial wastes and toxic products. Since municipal limits of Srinagar does not have effective drainage system most of the wastes enter into Dal and cause pollution.

Table 10. Seweage treatment plants in the catchment of Dal Lake (Source: Irrigation and flood control Dept., Srinagar).

S. No.	Name of the STP	Capacity
1.	STP Habbak	3.20 MLD
2.	STP Hazratbal	7.50 MLD
3.	STP Nallah Amir Khan	5.40 MLD
4.	STP Brarinambal	16.10 MLD
5.	STP Laam	4.50 MLD
	Total	**36.70 MLD**

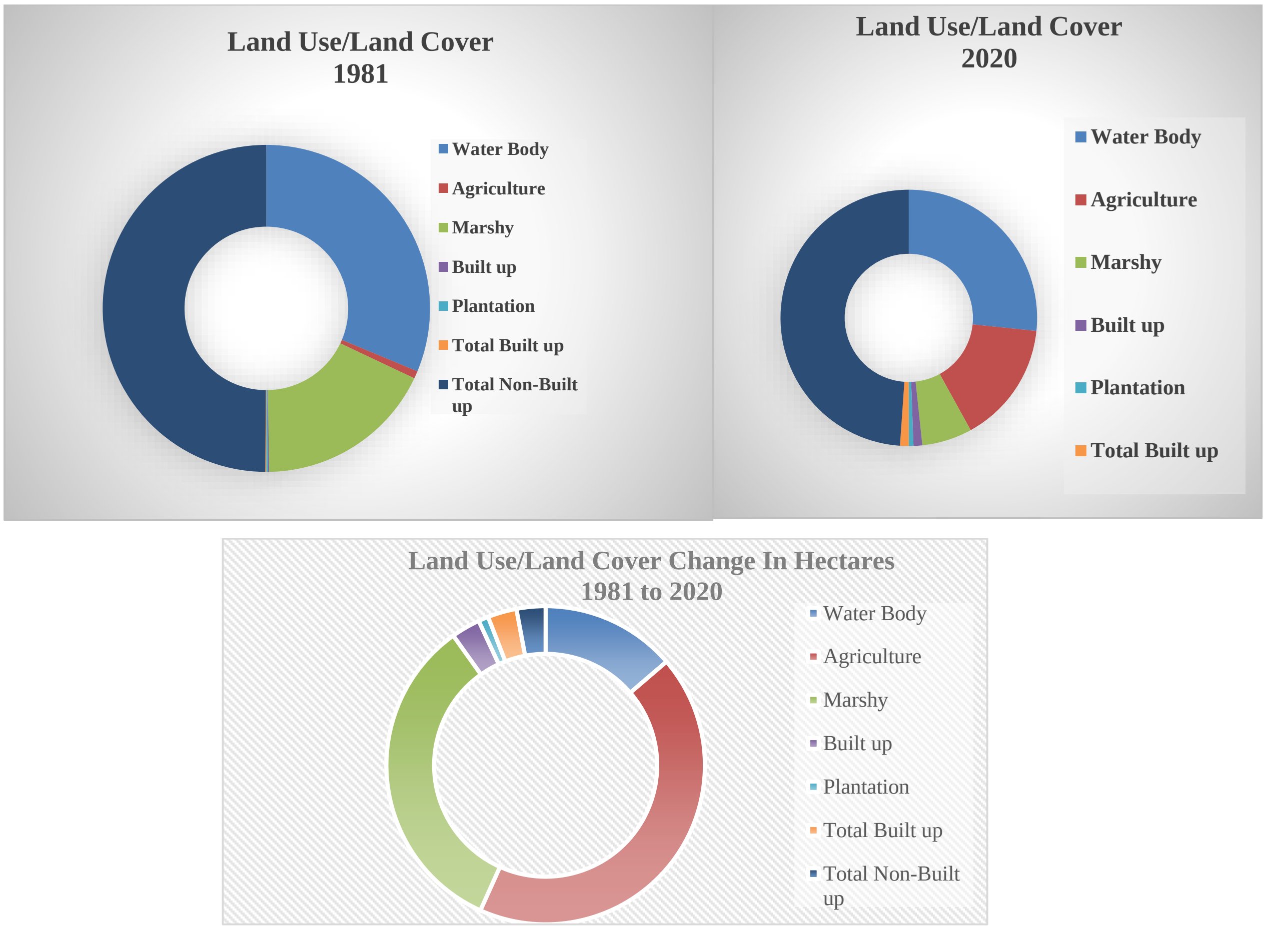
Dal Lake is an example of how land usage has changed over time. Environmental problems have arisen as a result of changes in land use, human settlements, fertilizer and pesticide discharge into the watershed, which seems almost difficult to manage now (Sheikh et. al., 2008). The local people exploit the water body non-judiciously for boating, shikara riding, fishing, waste dumping which include industrialand sewage wastes and macrophyte harvesting thereby threatening its gene pool (Fazal and Amin, 2012). The Jammu and Kashmir lakes and Waterways Development authority has installed almost five sewage treatment plants with a total capacity of 36.7 MLD for the effective management and conservation of the water body (Table 10). The fact that pesticides like BHC, which have been prohibited all across the world, are still in use at an alarmingly high rate reflects the ignorance of stake holders. These changes in land use classes have had a variety of consequences for the lake ecology and water quality (Khan and Shah, 2004; Rather and Dar, 2020).

The current study emphasizes the importance of an integrated watershed treatment approach for minimizing surface run-off as well as reducing erosion and nutrient loss in the catchment of the water body (Khan, 2000). Minimizing nutrient losses, and following contemporary protocols of Integrated pest management (IPM) and launching awareness

Programs by involving media, and other social platforms for the effective conservation of the

Dal Lake (Khan et al., 2004).

Land Use/Land Cover



Land Use/Land Cover Change In Hectares 1981 to 2020

Fig. 7-9: Land use/ cover change from 1981-2020

The land pattern around of the Dal has revealed that the built-up area has increased from 5.0 hectares in 1981 to 54.0 hectares in 2020. The willow and popular plantation in the catchment of Dal Lake has increased from 8.5 to 28.5 hectares during the periods from 1981- 2020 (Table 4). From the above results, it is clear that the land transformation of Dal Lake has taken place thereby converting the open water body into marshy lands which has negatively impacted the water chemistry and the dwelling flora of the Dal Lake. The land use chage pattern from the year 1981-

2020 is shown in the (Figures 7, 8 and 9) above.

6.2. Survey characteristics of anthropogenic activity in the vicinity of Dal Lake

A survey was conducted in the catchment of the Dal Lake and eleven related questions were asked to the respondents about the different factors which are responsible for the deterioration of the lake.

Table 11. Effect of slit clearance on the morphology and aquatic life of Dal Lake.

S. No.	Category	Percentage	Number	P value
1.	**Strongly agree**	21.3	78.7	p< 0.0003
2.	**Agree**	27.1	72.9	
3.	**Neither agree nor disagree**	34.7	65.3	
4.	**Disagree**	10.7	89.3	
5.	**Strongly disagree**	6.2	93.8	

21.3% of the people strongly agreed with the opinion that slit clearance in lakes change the morphology and hamper aquatic flora and fauna and 6.2% of the respondents strongly disagreed for the same. A highly significant difference at ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 12. Urban surface runoff and the threats to the biodiversity of the lake

S. No.	Category	Percentage	Number	P value
1.	**Strongly agree**	21.8	78.2	p<0.0001
2.	**Agree**	23.6	76.4	
3.	**Neither agree nor disagree**	16.9	83.1	
4.	**Disagree**	16.4	83.6	
5.	**Strongly disagree**	21.3	78.7	

21.8% of the people strongly agreed with the opinion that urban surface runoff is the main threat to the biodiversity of the lake and 21.3% of the respondent people strongly disagreed for the same. A highly significant difference (SD) ($P \leq 0.05$) was found between the categories of people for the same question.

Table 13. Problems due to urbanization around the Lake.

S. No.	Category	Percentage	Number	P value
1.	**Strongly agree**	10.2	89.8	p<0.0277
2.	**Agree**	14.7	85.3	
3.	**Neither agree nor disagree**	62.2	37.8	
4.	**Disagree**	4.9	95.1	
5.	**Strongly disagree**	8.0	92	

10.2% of the people strongly agreed with the opinion that urbanization is a major problem in the study area and 8.0% of the respondents strongly disagreed for the same. A highly significant difference (SD) at ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 14. Problems due to population growth around the Lake.

S. No.	Category	Percentage	Number	P value
1.	**Strongly agree**	31.1	68.9	p< 0.0001
2.	**Agree**	16.0	86	
3.	**Neither agree nor disagree**	25.8	74.2	
4.	**Disagree**	11.1	88.9	
5.	**Strongly disagree**	16.0	86	

31.1% of the people strongly agreed with the opinion that population growth may have adverse impact on the development of lakes and 16.0% of the respondents strongly disagreed for the same, similarly, 25.8% neither agreed nor disagreed for this opinion. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 15. Problems due to unemployment.

S. No.	Category	Percentage	Number	P value
1.	**Strongly agree**	8.9	91.1	p< 0.0002
2.	**Agree**	18.7	81.3	
3.	**Neither agree nor disagree**	26.7	73.3	
4.	**Disagree**	30.7	69.3	
5.	**Strongly disagree**	15.1	84.9	

8.9% of the people strongly agreed with the opinion that unemployment may have adverse impact on the development of lakes and 15.0% of the respondents strongly disagreed for the same, similarly, 26.7% neither agreed nor disagreed for this opinion. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 16 Problems due to negligence of local administration.

S. No.	Category	Percentage	Number	P value
1.	**Strongly agree**	8.9	91.9	p<0.0068
2.	**Agree**	14.2	85.8	
3.	**Neither agree nor disagree**	19.1	80.9	
4.	**Disagree**	36.0	64	
5.	**Strongly disagree**	21.8	78.2	

8.9% of the people strongly agreed with the opinion that negligence of local administration and 21.8% of the respondents strongly disagreed for the same, similarly, 19.8% neither agreed nor disagreed for this opinion. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 17. Awareness of the people about heavy pollution load and water quality deterioration.

S. No.	Category	Percentage	Number	P value
1.	**Strongly agree**	23.1	76.9	p< 0.0054
2.	**Agree**	29.3	70.7	
3.	**Neither agree nor disagree**	19.1	80.9	
4.	**Disagree**	15.6	84.4	
5.	**Strongly disagree**	12.9	87.1	

23.1% of the people strongly agreed with the opinion that the inhabitants of the catchment aware about the heavy pollution load and water quality deterioration and 12.9% of the respondents strongly disagreed for the same, similarly, 12.9% neither agreed nor disagreed for this opinion. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 18. Impact of habitation on the ecology of Dal Lake.

S. No.	Category	Percentage	Number	P value
1.	**High**	50.7	49.3	p<0.0544
2.	**Moderate**	28.9	71.1	
3.	**Less**	6.7	22.2	
4.	**No**	9.3	90.7	
5.	**Strong**	4.4	95.6	

50.7% of the people strongly agreed that Impact of habitation on the ecology of Dal Lake is very high and 28.9% of the respondents perceived the impact to moderate level. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 19. Potability of Dal lake water for drinking purposes.

S. No.	Category	Percentage	Number	P value
1.	**Strongly agree**	1.34	98.66	p< 0.0015
2.	**Agree**	33.8	66.2	
3.	**Neither agree nor disagree**	6.2	93.8	
4.	**Disagree**	48.4	51.6	
5.	**Strongly disagree**	10.2	89.8	

1.34% of the people strongly agreed with the opinion that water is still potable for drinking purposes and 10.2% of the respondents strongly disagreed for the same, similarly, 6.2% neither agreed nor disagreed for this opinion. A highly significant difference (SD) ($P \leq 0.05$) was found between the categories of people for the same question.

Table 20. Effect of pollution on Dal Lake.

S. No.	Category	Percentage	Number	P value
1.	**High**	54.7	45.3	p< 0.0034
2.	**Very high**	32.4	67.6	
3.	**Moderately**	1.8	98.2	
4.	**Marginally**	9.8	90.2	
5.	**Not at all**	1.3	98.7	

54.4% of the people believe that Dal Lake is highly polluted and32.4% of the respondents think that it is highly polluted, similarly, 9.8% think that it is marginally polluted. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 21. Ranking of problems due to solid waste.

S. No.	Category	Percentage	Number	P value
1.	**Important**	14.2	85.8	
2.	**Very important**	15.6	84.4	

3.	**Most important**	6.2	93.8	p< 0.0001
4.	**Somewhat important**	37.3	62.7	
5.	**Least important**	26.7	73.3	

14.2% of the people believed that management of solid waste is important to restore the glory of Dal Lake and 15.9% of the respondents believe that it is very important. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 22. Ranking of problems due to rampant use of fertilizers and pesticides.

S. No.	Category	Percentage	Number	P value
1.	**Important**	31.1	68.9	p< 0.0001
2.	**Very important**	23.1	76.9	
3.	**Most important**	32.9	67.1	
4.	**Somewhat important**	8.0	92	
5.	**Least important**	4.9	95.1	

31.1% of the people believed that rampant use off fertilizers has destroyed the beauty of Dal and 23.1% of the respondents believe that it is very important and 4.9 % think it is least important. A highly significant difference ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 23. Ranking of problems due to municipal wastes.

S. No.	Category	Percentage	Number	P value
1.	**Important**	45.8	54.2	p< 0.0016
2.	**Very important**	37.8	62.2	
3.	**Most important**	5.8	94.2	
4.	**Somewhat important**	8.9	91.1	
5.	**Least important**	1.8	98.2	

45.8% of the people believed that management of muncipal waste is important to get back the original shape of Dal Lake and 37.8% of the respondents believe that it is very important and 1.8% think it is least important. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 24. Ranking of problems due to illegal fishing.

S. No.	Category	Percentage	Number	P value
1.	**Important**	26.2	73.8	p< 0.0001
2.	**Very important**	18.7	81.3	
3.	**Most important**	34.7	65.3	
4.	**Somewhat important**	7.1	92.9	
5.	**Least important**	13.3	86.7	

26.2% of the people said that illelgal fishing must be restricted for restoring Dal and 18.7% of the respondents believe that it is very important and 13.3 % think it is least important. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 25. Ranking of problems due to house hold runoff.

S. No.	Category	Percentage	Number	P value
1.	**Important**	11.6	88.4	p< 0.0001
2.	**Very important**	28.4	71.6	
3.	**Most important**	35.6	64.4	
4.	**Somewhat important**	16.9	83.1	
5.	**Least important**	7.6	92.4	

11.6% of the people belive that household run off must be restricted in Dal and 28.4% of the respondents believe that it is very important and 7.6 % think it is least important. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 26. Ranking of problems due to deforestation.

S. No.	Occupation	Percentage	Number	P value
1.	**Important**	21.3	78.7	p< 0.0001
2.	**Very important**	27.1	72.9	
3.	**Most important**	34.7	65.3	
4.	**Somewhat important**	10.7	89.3	
5.	**Least important**	6.2	93.8	

21.3% of the people believe that deforestration has caused problems for Dal and 27.1% of the respondents believe that it is very important and 6.2% think it is least important. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 27. Ranking of problems due to solid waste pollution.

S. No.	Category	Percentage	Number	P value
1.	**Important**	22.2	77.8	p< 0.0001
2.	**Very important**	23.6	76.4	
3.	**Most important**	16.4	83.6	
4.	**Somewhat important**	16.4	83.6	
5.	**Least important**	21.3	78.7	

22.2% of the people believe that solid waste pollution has caused problems for Dal and 23.6% of the respondents believe that it is very important and 21.3% think it is least important. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 28. Ranking of problems due to encroachment.

S. No.	Category	Percentage	Number	P value
1.	**Important**	10.2	89.8	p< 0.0041
2.	**Very important**	14.7	85.3	
3.	**Most important**	62.2	37.8	
4.	**Somewhat important**	4.9	95.1	
5.	**Least important**	8.0	92	

10.2% of the people believe that encroachment has caused problems for Dal and 14.7% of the respondents believe that it is very important and 8.0% think it is least important. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 29. Ranking of problems due to sewage (household runnoff).

S. No.	Category	Percentage	Number	P value
1.	**Important**	31.1	68.9	p< 0.0001
2.	**Very important**	16.0	84	
3.	**Most important**	25.8	74.2	
4.	**Somewhat important**	11.1	88.9	
5.	**Least important**	16.0	84	

31.1% of the people believe that sewage has caused problems for Dal and 16.0% of the respondents believe that it is very important and 16.0% think it is least important. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 30. Ranking of problems due to washing and bathing.

S. No.	Category	Percentage	Number	P value
1.	**Important**	18.7	81.3	p< 0.0002
2.	**Very important**	31.6	68.4	
3.	**Most important**	37.8	62.2	
4.	**Somewhat important**	5.8	94.2	

5.	**Least important**	6.2	93.8	

18.7% of the people believe that washing and bathing has caused problems for Dal and 31.6% of the respondents believe that it is very important and 6.2% think it is least important. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 31. Ranking of problems due to solid waste dumping

S. No.	Category	Percentage	Number	P value
1.	**Important**	24.4	75.6	p< 0.0001
2.	**Very important**	22.2	77.8	
3.	**Most important**	24.9	75.1	
4.	**Somewhat important**	15.6	84.4	
5.	**Least important**	12.9	87.1	

24.4% of the people believe that dumping of waste has caused problems for Dal and 22.2% of the respondents believe that it is very important and 6.2% think it is least important. A highly significant difference (SD) ($P \leq 0.05$) was observed between the categories of people for the same question.

Table 32. Ranking of problems due to latrines and open defection.

S. No.	Category	Percentage	Number	P value
1.	**Important**	27.6	72.4	p< 0.0001
2.	**Very important**	24.9	75.1	
3.	**Most important**	19.6	80.4	
4.	**Somewhat important**	16.0	84	
5.	**Least important**	12.0	88	

27.6% of the people believe that latrines and open defecation has caused problems for Dal and 24.9% of the respondents believe that it is very important and 12.0% think it is least important.

A highly significant difference (SD) (P ≤ 0.05) was observed between the categories of people for the same question.

Table 33. Effect of increasing population on water quality deterioration.

S. No.	Category	Percentage	Number	P value
1.	**Strongly agree**	12.0	88	p< 0.0005
2.	**Agree**	24.4	75.6	
3.	**Neither agree nor disagree**	47.6	52.4	
4.	**Disagree**	10.2	89.8	
5.	**Strongly disagree**	5.8	94.2	

12.0% of the people strongly agreed with the opinion that the increase in population along the catchment responsible for deteriorating water quality and 24.4% of the respondents strongly disagreed for the same, similarly, 5.8% neither agreed nor disagreed for this opinion. A highly significant difference (SD) (P ≤ 0.05) was observed between the categories of people for the same question.

Table 34. Challenging impact of threats on the public and government

S. No.	Category	Percentage	Number	P value
1.	**Strongly agree**	25.8	74.2	p< 0.1954
2.	**Agree**	23.6	76.4	
3.	**Neither agree nor disagree**	19.6	804	
4.	**Disagree**	18.7	81.3	
5.	**Strongly disagree**	12.4	87.6	

25.8% of the people strongly agreed with the opinion that threats mentioned above challenging to the public and government and 23.6% of the respondents strongly disagreed for the same, similarly, 12.4% neither agreed nor disagreed for this opinion. A non significant difference (SD) (P ≤ 0.05) was observed between the categories of people for the same question.
In order to estimate the impact of anthropogenic activity on the ecology and well being of the Dal Lake a questionnaire based on five-point Likert scale was developed and a host of

questions were asked to the stakeholders regarding the different factors which contribute to the deteriorating ecological condition of the lake. The results of this survey are given in the (Tables 11-34). As can be explicitly y seen from the results the stakeholders gave the responses ‘Agreed strongly’ or ‘agreed’ to the questions like does slit, clearance of the lake effect its physiognamy and flora and fauna and surface runoff, urbanization, fertilizers and pesticides usage, construction of latrine and open defections on the banks of lake and increased population in the catchment compromise with the carrying capacity of the lake. The responses recorded were from the stakeholders, were in close conformity with the changing biochemical parameters of the water body.

Filled sample Questionnaires

DEPARTMENT OF BOTANY
SCHOOL OF BIOENGINEERING AND BIOSCIENCES
LOVELY PROFESSIONAL UNIVERSITY, JALANDHAR,PUNJAB.

Questionnaire for assessing the perceptions of respondents with regard to Anthropogenic Interventions on Dal Lake, Srinagar

We are carrying out a survey for which we need to ask you a few questions. The answer that you may provide will be used to generate scientific information in developing the possible management strategies for long lasting sustainability of the Dal Lake.

1. **Respondents Name: Mr./Mrs./Ms** .... Dr. Fayaz
2. **Address:** .... [illegible]
3. **Gender:** .... Male
4. **Age:** 36
5. **Occupation:** .... Teaching
6. **Qualification:** .... M.Phil
7. **Contact:** 9596960854
8. **Email ID:** ....

1. The execution of channelization and slit clearance in stream changes its morphology and makes the lake bed uneven which affects the water flow and subsequently hampers the aquatic flora and fauna.
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree
2. Urban surface runoff is the main threat to the biodiversity of the lake?
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree
3. How would you rank the following ecological/social problems which are responsible for polluting the water body?

Problems	Ranking
a. Urbanization	3
b. Population growth	2
c. Unemployment	4
d. Negligence of local administration	2

1. Important **2. Very Important** **3. Most Important** **4. Somewhat Important** **5. Least Important**

5. The inhabitants along the catchment area of the said lake are not aware about the consequences of heavy pollution load like soil erosion, loss of important species, economic loses and water quality deterioration?
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree
6. What according to you is the Impact of habitation on the ecology of Dal lake.
   1. High
   2. Moderate
   3. Less
   4. No
   5. Strong
7. The Lake water is still potable for drinking purpose.
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree

8. To what extent the Dal lake is polluted.
1. High
2. Very high
3. Moderately
4. Marginally
5. Not at all

9. How would you rank the following pollutants in terms of threat that the lake is facing according to their order of importance.

Problems	Ranking
a. Solid wastes	2
b. Rampant use of fertilizers & pesticides	3
c. Municipal wastes	1
d. Illegal fishing(Like electric current & chemicals)	3
e. Household run-off (Sewage)	2

1. Important **2. Very Important** **3. Most Important** **4. Somewhat Important** **5. Least Important**

10. How would you rank the following problems in terms of importance which is more responsible for deteriorating the water quality of the said lake?

Problems	Ranking
a. Deforestation	4
b. Solid Waste Pollution e.g. Polythene	2
c. Encroachment	3
d. Sewage (Household run-off)	1
e. Washing and bathing	2
f. Solid waste dumping	3
g. Built latrines and open defecation on banks	4

1. Important **2. Very important** **3. Most important** **4. Somewhat important** **5. Least important**

11. The continuous increase in population growth along the catchment area of the said lake has also increased the anthropogenic disturbances which is subsequently deteriorating the water quality and aquatic diversity.

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

12. The threats mentioned in the said questionnaire are challenges for the public in general and government in particular
1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Fayaz
Signature

DEPARTMENT OF BOTANY
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We are carrying out a survey for which we need to ask you a few questions. The answer that you may provide will be used to generate scientific information in developing the possible management strategies for long lasting sustainability of the Dal Lake.

1. **Respondents Name: Mr./Mrs./Ms** Dr. Khursheed Wani
2. **Address:** Nambu Pulwama
3. **Gender:** Male
4. **Age:** 36
5. **Occupation:** Asst. Prof
6. **Qualification:** Ph.D
7. **Contact:** 9602169453
8. **Email ID:**

1. The execution of channelization and slit clearance in stream changes its morphology and makes the lake bed uneven which affects the water flow and subsequently hampers the aquatic flora and fauna.
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree

2. Urban surface runoff is the main threat to the biodiversity of the lake?
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree

3. How would you rank the following ecological/social problems which are responsible for polluting the water body?

Problems	Ranking
a. Urbanization	3
b. Population growth	4
c. Unemployment	5
d. Negligence of local administration	2

1. Important 2. Very Important 3. Most Important 4. Somewhat Important 5. Least Important

5. The inhabitants along the catchment area of the said lake are not aware about the consequences of heavy pollution load like soil erosion, loss of important species, economic loses and water quality deterioration?
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree

6. What according to you is the Impact of habitation on the ecology of Dal lake.
   1. High
   2. Moderate
   3. Less
   4. No
   5. Strong

7. The Lake water is still potable for drinking purpose.
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree

8. To what extent the Dal lake is polluted.
1. High
2. Very high
3. Moderately
4. Marginally
5. Not at all

9. How would you rank the following pollutants in terms of threat that the lake is facing according to their order of importance.

Problems	Ranking
a. Solid wastes	4
b. Rampant use of fertilizers & pesticides	5
c. Municipal wastes	2
d. Illegal fishing(Like electric current & chemicals)	5
e. Household run-off (Sewage)	2

1. Important **2. Very Important** **3. Most Important** **4. Somewhat Important** **5. Least Important**

10. How would you rank the following problems in terms of importance which is more responsible for deteriorating the water quality of the said lake?

Problems	Ranking
a. Deforestation	2
b. Solid Waste Pollution e.g. Polythene	2
c. Encroachment	3
d. Sewage (Household run-off)	2
e. Washing and bathing	5
f. Solid waste dumping	4
g. Built latrines and open defecation on banks	3

1. Important **2. Very important** **3. Most important** **4. Somewhat important** **5. Least important**

11. The continuous increase in population growth along the catchment area of the said lake has also increased the anthropogenic disturbances which is subsequently deteriorating the water quality and aquatic diversity.

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

12. The threats mentioned in the said questionnaire are challenges for the public in general and government in particular
1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Khursheed

Signature

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Questionnaire for assessing the perceptions of respondents with regard to Anthropogenic Interventions on Dal Lake, Srinagar

We are carrying out a survey for which we need to ask you a few questions. The answer that you may provide will be used to generate scientific information in developing the possible management strategies for long lasting sustainability of the Dal Lake.

1. **Respondents Name: Mr./Mrs./Ms** ……Sajadul Haq……
2. **Address:** ……Pulwama……
3. **Gender:** ……Male……
4. **Age:** ……40……
5. **Occupation:** ……Teacher……
6. **Qualification:** ……Ph.D……
7. **Contact:** ……9596147778……
8. **Email ID:** ……………………

1. The execution of channelization and slit clearance in stream changes its morphology and makes the lake bed uneven which affects the water flow and subsequently hampers the aquatic flora and fauna.
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree
2. Urban surface runoff is the main threat to the biodiversity of the lake?
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree
3. How would you rank the following ecological/social problems which are responsible for polluting the water body?

Problems	Ranking
a. Urbanization	3
b. Population growth	3
c. Unemployment	2
d. Negligence of local administration	5

1. Important **2. Very Important** **3. Most Important** **4. Somewhat Important** **5. Least Important**

5. The inhabitants along the catchment area of the said lake are not aware about the consequences of heavy pollution load like soil erosion, loss of important species, economic loses and water quality deterioration?
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree
6. What according to you is the Impact of habitation on the ecology of Dal lake.
   1. High
   2. Moderate
   3. Less
   4. No
   5. Strong
7. The Lake water is still potable for drinking purpose.
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree

8. To what extent the Dal lake is polluted.
   1. High
   2. Very high
   3. Moderately
   4. Marginally
   5. Not at all

9. How would you rank the following pollutants in terms of threat that the lake is facing according to their order of importance.

Problems	Ranking
a. Solid wastes	2
b. Rampant use of fertilizers & pesticides	5
c. Municipal wastes	4
d. Illegal fishing(Like electric current & chemicals)	5
e. Household run-off (Sewage)	3

1. Important 2. Very Important 3. Most Important 4. Somewhat Important 5. Least Important

10. How would you rank the following problems in terms of importance which is more responsible for deteriorating the water quality of the said lake?

Problems	Ranking
a. Deforestation	1
b. Solid Waste Pollution e.g. Polythene	3
c. Encroachment	4
d. Sewage (Household run-off)	2
e. Washing and bathing	5
f. Solid waste dumping	3
g. Built latrines and open defecation on banks	4

1. Important 2. Very important 3. Most important 4. Somewhat important 5. Least important

11. The continuous increase in population growth along the catchment area of the said lake has also increased the anthropogenic disturbances which is subsequently deteriorating the water quality and aquatic diversity.

   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree

12. The threats mentioned in the said questionnaire are challenges for the public in general and government in particular
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree

Sajad
Signature

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We are carrying out a survey for which we need to ask you a few questions. The answer that you may provide will be used to generate scientific information in developing the possible management strategies for long lasting sustainability of the Dal Lake.

1. **Respondents Name: Mr./Mrs./Ms** ....Burhan Ahmad........
2. **Address:** ....Anantnag........
3. **Gender:** ....Male........
4. **Age:** ....29........
5. **Occupation:** ....Teacher........
6. **Qualification:** ....M.Sc........
7. **Contact:** ....
8. **Email ID:** ....

1. The execution of channelization and slit clearance in stream changes its morphology and makes the lake bed uneven which affects the water flow and subsequently hampers the aquatic flora and fauna.
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree
2. Urban surface runoff is the main threat to the biodiversity of the lake?
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree
3. How would you rank the following ecological/social problems which are responsible for polluting the water body?

Problems	Ranking
a. Urbanization	4
b. Population growth	3
c. Unemployment	2
d. Negligence of local administration	5

1. Important 2. Very Important 3. Most Important 4. Somewhat Important 5. Least Important

5. The inhabitants along the catchment area of the said lake are not aware about the consequences of heavy pollution load like soil erosion, loss of important species, economic loses and water quality deterioration?
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree
6. What according to you is the Impact of habitation on the ecology of Dal lake.
   1. High
   2. Moderate
   3. Less
   4. No
   5. Strong
7. The Lake water is still potable for drinking purpose.
   1. Strongly Agree
   2. Agree
   3. Neither Agree nor Disagree
   4. Disagree
   5. Strongly Disagree

8. To what extent the Dal lake is polluted.

1. High
2. Very high
3. Moderately
4. Marginally
5. Not at all

9. How would you rank the following pollutants in terms of threat that the lake is facing according to their order of importance.

Problems	Ranking
a. Solid wastes	3
b. Rampant use of fertilizers & pesticides	5
c. Municipal wastes	2
d. Illegal fishing(Like electric current & chemicals)	5
e. Household run-off (Sewage)	1

1. Important 2. Very Important 3. Most Important 4. Somewhat Important 5. Least Important

10. How would you rank the following problems in terms of importance which is more responsible for deteriorating the water quality of the said lake?

Problems	Ranking
a. Deforestation	1
b. Solid Waste Pollution e.g. Polythene	3
c. Encroachment	2
d. Sewage (Household run-off)	5
e. Washing and bathing	3
f. Solid waste dumping	4
g. Built latrines and open defecation on banks	3

1. Important 2. Very important 3. Most important 4. Somewhat important 5. Least important

11. The continuous increase in population growth along the catchment area of the said lake has also increased the anthropogenic disturbances which is subsequently deteriorating the water quality and aquatic diversity.

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

12. The threats mentioned in the said questionnaire are challenges for the public in general and government in particular

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree

Burhan
Signature

6.3. Identification and classification of macrophytes growing in the Dal Lake

During the current study nineteen species of macrophytes have been recorded along the four stations of the Dal Lake and classified into different groups such as emergents, submerged, free floating and rooted floating types. The current study emphasizes the importance of an integrated watershed treatment approach for minimizing surface run-off, reducing erosion and nutrient loss in the catchment. These goals can be met by taking concrete steps for management and conservation (Khan, 2000; Jeelani and Kour, 2008). Eroding pastures (fallow land) to reduce grazing pressures, massive aforestation to conserve soil and minimize nutrient loss, biological pest control using the integrated pest management programme, with the active participation of the media, both print and electronic, as well as non-governmental organisations (NGOs) for the urgent ecorestoration of the wetland. The macrophytes constitute an important part of any waterbody which add beauty and have the sequestration properties (Lolu, 2019). The brief description of the identified macrophytes is given in the (Table 35).

Table 35. Description and classification of macrophytes in to different categories in the Dal Lake.

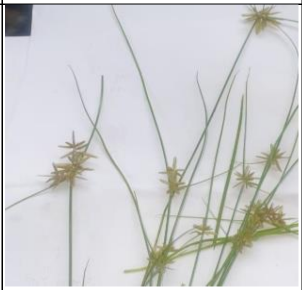
Name of the Plant Species	Common name	Category	Photograph	Identification| Description
Azolla sp. Lam. (Salviniaceae)	Mosquito fern	Free floating		*Azolla* is a little triangular fern with 2.5-centimeter-long fronds that float on the water surface. The frond features 1 or 2 millimeter long overlapping green or dark red leaves that are rounded or angular. Because of its ability to fix nitrogen, the fern can thrive in low-nitrogen environments (Evrard and Hove, 2004).
Ceratophyllum demersum L. (Ceratophylaceae)	Horn wort	Submerged		*Ceratophyllum demersum* stems are 1–3 m (3–10 ft) in length and have a bushy look due to numerous side branches. The 8–40 mm long leaves of the plant are produced in whorls of six to twelve. The fruit is a little nut that is 4–5 mm long, and the shrub is monoecious. The defining trait of the plant is the development of turions (Global Invasive Species database, 2006).

Hydrocharis dubia L. (Hydrocharitaceae)	Frogbit	Submerged		*Hydrocharis dubia* is a freshwater herb that can float or remain rooted. Leaf stalks are up to 12cm long and connected to the leaf blades. The leaves are 2-7cm long, thick, glossy, and widely oval to round in form (Cook and Luond, 1982).
Myriophyllum spicatum L. (Haloragaceae)	Watermilfoil	Submerged		The leaves of *Myriophyllum spicatum* are present in thread like pinnate whorls of four in number 4–13 mm long leaflets, and the stems are up to 250 centimeters long. Plants of *Myriophyllum* are monoecious, and the flowers produced in the axils of leaf (Moody and Les, 2007).
Nelumbo nucifera L. (Nelumbonaceae)	Indian lotus	Rooted floating		Lotus plants thrive on slow-moving river floodplains. Under ideal conditions, the seeds of these plants can last for hundreds of years, with the oldest record dating back to 1,300 years. Pinkish flowers are produced by the Lotus plant (Cook and Christopher, 1974).

Nymphaea alba L. (Nymphaeaceae)	White water lily	Rooted floating		*Nymphaea alba* is found in large ponds and lakes, where it grows in 30–150 cm deep waters. The plant leaves are around 30 cm in diameter, and its flowers are white in colour (Akhani, 2014).
Nymphoides peltata L. (Menyanthaceae)	Floating heart	Rooted floating		*Nymphoides peltata* is a perennial bottom-rooted plant with up to 2-meter-long submerged stolons. It has five-petaled flowers on its inflorescence. The flowers produce a 1.5-2.5 cm beak like capsule with stiff marginal hairs that hold many flattened seeds. (Sivarajan and Joseph, 1993).
Potamogeton crispus L. (Potamogetonaceae)	Curly pond weed	Submerged		*Potamogeton crispus* is a perennial rhizomatous herb with a meter-long flattened, branching stem. The leaves are oblong or linear in shape, and only linear, or oblong submerged leaves are produced. Turions are attached to leaf axils and stem terminals (Preston, 1995).

Trapa natans L. (Lythraceae)	Singhara nut	Rooted floating		*Trapa natans* produces stem, which is linked to the mud via roots and can reach a length of 3.7 to 4.6 meters. Feather-like leaves which are submerged and undivided floating leaf types are the two types of leaves. The flowers have four petals and are white in colour. They are used as a food source (Karg, 2006).
Potamogeton lucens L. (Potamogetonaceae)	Shining pond weed	Submerged		*Potamogeton lucens* is a large, creeping rhizome-producing plant. The stem produces terete branching up to 2.5 metres. The floating leaves are missing, and the leaves are 75–200 mm long and pale green or yellowish in colour. (Preston, 1995).
Salvinia natans L. (Salviniaceae)	Floating fern	Free floating		*Salvinia natans* is a small floating aquatic species with creeping stems and leaf surface hairs. They have no true roots, and their leaves grow in trimerous whorls (Joyce McCauley, 2001).

Typha angustata L. (Typhaceae)	Leaf cattail	Emergent		It is an obligate wetland plant that thrives in brackish environments, with flat, narrow leaves and rhizomatous roots (Rook and Earl, 2004).
Phragmites australis (Cav.) Trin. ex Steud	The common reed	Emergent		*Phragmites* plants have large leaves and plume-like panicles, and they are used to make mats, screens, and arrow shafts. They are typically found in moist parts of temperate and tropical regions (Elias and Peter, 2009).
Lemna minor L. (Araceae)	Common duckweed	Free floating		*Lemna* grows just under or on the surface of water, they are seen as simple free floating aquatic types. The majority are little, measuring not more than 5 mm in length. The plants primarily reproduce vegetatively, with two daughter plants produced from the adult plant. When *Lemna* infests a canal, they can be mechanically removed by introducing herbivorous fishes (grass carp), it can also be used as a protein feed (Leng, 1995).

Sagitaria latifolia Willd. (Alismataceae)	Broad leaf Arrowhead	Emergent		Broadleaf arrowhead is a common emergent plant that develops dense colonies on very moist soils they prefer deeper water levels. Ducks rarely eat the tubers, which are normally buried too deep for them to reach, despite the moniker "duck potato." They do, however, eat the seeds (Niering and Nancy, 1985).
Cyperus sp. L. (Cyperaceae)	Umbrella sedges	Emergent		They are typically aquatic annual or perennial plants that grow in staginant or slow-moving water up to 0.5 m deep. The size of the species varies widely, with some being only 5 cm tall and others reaching a height of 5 meters. Greenish flowers are formed in bunches among the apical leaves and are pollinated by the wind. The seed is the size of a nutlet (Lansdown et al., 2017).
Carex sp.L. (Cyperaceae)	True sedges	Emergent		*Carex* species are perennial, though some, like *C. bebbii* and *C. viridula*, can fruit in their first year of growth and may not live much longer. Rhizomes, stolons, and short rootstocks are common. *Carex* flowers are small and grouped into spikes and bigger inflorescence (Robert et al., 1999).

Polygonum amphibium L. (Polygonaceae)	Water knotweed	Emergent		It is a rhizomatous perennial herb that comes in different shapes and sizes and has a wide range of morphology. The stems have been observed to exceed 3 meters (10 feet) in length. The stems are ribbed and can range in texture from hairless to fairly hairy (Flora of North America).
Nasturtium officinale (Brassicaceae)	Watercress	Emergent		Although molecular evidence suggests these watery species with hollow stems, some publications list watercress as belonging to the genus Rorippa. The leaves, stems, and fruit of watercress can all be eaten raw (Nyerges and Christopher, 2016).

Table 36. Importance value index of macrophytes during winter season.

S.No.	Name of the species	Relative frequency (RF)	Relative density (RD)	Relative abundance (RA)	Importance value index (IVI)
1	*Azolla* sp.	12.80	20.10	10.20	43.1
2	*Ceratophyllum demersum*	5.57	7.53	5.06	18.16
3	*Hydrocharis dubia*	2.26	3.71	3.06	9.03
4	*Myriophyllum spicatum*	5.27	8.95	6.86	21.08
5	*Nelumbo nucifera*	1.29	1.20	1.30	3.79
6	*Nymphaea alba*	5.27	2.84	5.96	14.07
7	*Nymphoides peltata*	10.24	16.71	13.28	40.23
8	*Potamogeton crispus*	7.98	2.18	1.71	11.87
9	*Trapa natans*	4.97	1.44	1.34	7.75
10	*Potamogeton lucens*	3.46	4.40	4.25	12.11
11	*Salvania natans*	1.80	1.33	1.59	4.72
12	*Typha angustata*	9.94	4.15	14.71	28.8
13	*Phragmites australis*	8.58	4.63	13.89	27.1
14	*Lemna minor*	11.75	17.37	9.80	38.92
15	*Sagitaria latifolia*	3.61	0.93	1.21	5.75
16	*Cyperus* sp.	1.29	1.20	1.09	3.58
17	*Carex* sp.	1.29	0.16	2.28	3.73
18	*Polygonum amphibium*	1.89	0.87	1.62	4.38
19	*Nasturtium officinale*	0.64	0.21	0.40	1.25

Spence (1967), failed to find any definite association between soil type and macrophytic distribution during his research on certain lochs of Scotland (United Kingdom). Submerged aquatic plants, on the other hand, grew better in organic-rich soils. During the current study the silty sections of Dal Lake appeared to be conducive to the colonization of floating leaf species but not to the development of submerged forms. The thicker rhizome of *Nymphaea stellata* at Dal Lake minimizes the likelihood of it being uprooted by biotic interference in soft sediments. While the continuing growth of rhizome and eventual decay of older parts act as an effective asexual means of spreading to the nearby areas which is the characteristic of this species for the formation of monospecfic communities (Talevska et al., 2009; Naseer et al., 2014).

The diverse mineral content of the sediments beneath the plant communities indicates that the species in question have a wide ecological range. The lack of horizontal sedimentary strata, combined with the heterogeneous nature of sediments containing organic matter in varying states of decomposition, prevents any plausible association between plant distribution and substrate features. Organic matter concentration is mostly associated with increased nitrogen levels (Kuiper et al., 2017).

Table 37. Importance value index of macrophytes during spring season.

S.No.	Name of the species	Relative frequency (RF)	Relative density (RD)	Relative abundance (RA)	Importance value index (IVI)
1	*Azolla* sp.	10.64	17.04	9.38	37.06
2	*Ceratophyllum demersum*	5.45	6.69	4.97	17.11
3	*Hydrocharis dubia*	2.85	2.56	2.22	7.63
4	*Myriophyllum spicatum*	5.97	7.69	6.74	20.4
5	*Nelumbo nucifera*	1.55	1.19	1.56	4.3
6	*Nymphaea alba*	4.28	3.57	6.18	14.03
7	*Nymphoides peltata*	9.60	22.54	15.50	47.64
8	*Potamogeton crispus*	7.26	2.10	1.66	8.92
9	*Trapa natans*	4.93	2.83	1.94	9.7
10	*Potamogeton lucens*	3.24	4.89	4.27	12.4
11	*Salvania natans*	1.68	2.04	1.44	5.16
12	*Typha angustata*	11.55	4.49	14.25	30.29
13	*Phragmites australis*	10.90	3.07	13.63	27.6
14	*Lemna minor*	10.51	13.95	9.03	33.49
15	*Sagitaria latifolia*	3.50	1.63	1.31	6.44
16	*Cyperus* sp.	1.46	1.68	1.15	4.29
17	*Carex* sp.	0.12	0.32	2.05	2.49
18	*Polygonum amphibium*	2.53	1.79	1.95	6.27
19	*Nasturtium officinale*	0.83	0.28	0.68	1.79

The importance of temperature in determining the development of vegetation cannot be overstated; greater water temperatures result in faster plant growth (Jenkin, 1942). The vegetational growth of Dal Lake has been found to be slowing as a result of the low temperatures that prevails in this water body for a long period at the start of the growing season. However, the increase in ambient temperature in the following months has a great impact on both the vegetational and phasic development of the plants. Temperature has a greater impact on the development of a large number of plant species during the summer and the death of all above ground shots during the winter (Sharma et al., 2015).

In wetland ecosystems, the hydrological component provides the primary set of conditions that promote the appearance and growth of numerous plant species and their interactions. Marshy plants prefer damp soil or water that is between 18 inches and 4 feet deep (Khan et al., 2004). Emergent growth at greater depths necessitates more energy for them to reach the surface, and if this additional energy demand is large enough, it might easily prove catastrophic (Bellrose 1941; Jeelani and Kaur, 2008). According to (Laing, 1941) and (Miller, 1973), the adaptation of different semi-submerged water plant species to different depths of water is at least partly due to the oxygen needs for maximal growth of the young shoots. Haslam (1973); Anjum and Mahajan (2009), reviewed the biology of *Phragmites communis*, and noticed that aeration occurred in the species through standing shoots, and that if ice or waves eliminated the autumn seed, the species only displayed a small amount of growth. *Typha augustifolia* dieback in Lake Erie wetlands was attributed by Mc Donald (1955) to the lack of oxygen caused by the submergence of the prominent shoots over the winter. Sculthrope (1967), described the occurrences of a gas transport system from leaves to roots and rhizomes, as well as the survival of below-ground structures under oxygen starving conditions to these transport processes. *Typha augustifolia* and *Juncus articulatus* have distinct water depth optima and reactions to wetland variation, although they all have substantial cover over a wide range of water depths (Morrison and Molofoky, 2000; Wetzel and Vender valk 1998; Talevska et al., 2009; Lawniczak et al., 2010).

Table 38. Importance value index of macrophytes during summer season.

S.No.	Name of the species	Relative frequency (RF)	Relative density (RD)	Relative abundance (RA)	Importance value index (IVI)
1	*Azolla* sp.	10.48	16.45	10.44	37.37
2	*Ceratophyllum demersum*	5.48	8.07	6.50	20.05
3	*Hydrocharis dubia*	3.09	2.99	2.89	8.97
4	*Myriophyllum spicatum*	6.19	7.92	7.17	21.28
5	*Nelumbo nucifera*	1.90	1.38	1.71	4.99
6	*Nymphaea alba*	4.52	3.99	7.51	16.02
7	*Nymphoides peltata*	9.29	21.07	17.50	47.86
8	*Potamogeton crispus*	7.03	2.61	2.08	11.72
9	*Trapa natans*	5.36	3.30	2.49	11.15
10	*Potamogeton lucens*	3.45	2.92	4.88	11.25
11	*Salvania natans*	1.66	2.46	0.33	4.45
12	*Typha angustata*	10.84	0.18	17.51	28.53
13	*Phragmites australis*	10.60	2.46	16.36	29.42
14	*Lemna minor*	9.89	14.86	9.76	34.51
15	*Sagitaria latifolia*	3.81	1.01	1.44	6.26
16	*Cyperus* sp.	1.46	1.53	1.38	4.37
17	*Carex* sp.	1.96	1.06	2.10	5.03
18	*Polygonum amphibium*	2.06	1.38	2.00	5.44
19	*Nasturtium officinale*	0.81	0.14	0.66	1.61

Due to little harvesting of this species, *Phragmites comminis* grows in tall and vigorous stands in Dal Lake, the restriction of the species to isolated stands is however a result of the disadvantageous water depth (Parray et al., 2021). The broad changes in vegetation that occur as a result of different water level regimes are well known (Flowers and Evans 1966; Steward and Kantrude, 1971; Naseer et al., 2014). Water level oscillations generate an exceedingly unstable environment for plant growth, both within and between seasons. The water level consistency in the Dal Lake wetland was ideal for the completion of the numerous biological (Shah et al., 2014). The number and density of *Polygonum amphibium* increased as the water level dropped in the late growing season.

Table 39. Importance value index of macrophytes during autumn season.

S.No.	Name of the species	Relative frequency (RF)	Relative density (RD)	Relative abundance (RA)	Importance value index (IVI)
1	*Azolla* sp.	10.64	16.42	6.82	33.81
2	*Ceratophyllum demersum*	5.99	12.25	6.29	24.53
3	*Hydrocharis dubia*	2.93	3.08	2.13	8.14
4	*Myriophyllum spicatum*	6.60	9.50	6.05	22.15
5	*Nelumbo nucifera*	1.71	1.33	1.45	4.49
6	*Nymphaea alba*	5.01	5.33	7.26	17.6
7	*Nymphoides peltata*	7.71	11.25	9.85	28.81
8	*Potamogeton crispus*	7.83	3.25	2.16	13.24
9	*Trapa natans*	5.63	4.00	2.34	11.97
10	*Potamogeton lucens*	2.93	2.25	3.47	8.65
11	*Salvania natans*	1.34	2.00	1.12	4.46
12	*Typha angustata*	11.38	0.32	18.60	30.3
13		10.77	4.15	17.76	32.68
14	*Lemna minor*	9.05	14.40	8.01	31.46
15	*Sagitaria latifolia*	3.18	1.00	1.15	5.33
16	*Cyperus* sp.	1.32	1.30	1.41	4.03
17	*Carex* sp.	1.73	1.18	1.73	4.64
18	*Polygonum amphibium*	3.45	1.45	1.71	6.61
19	*Nasturtium officinale*	0.70	0.11	0.52	1.33

Although a number of factors have been found to have an impact on the growth and dispersion of submerged plant species (Sculthorpe, 1967), water depth (Spence, 1967; Talevska et al., 2009) floods (Edwards, 1969), and drawdown (Nichols, 1974) have all been mentioned. The heavy load of slit brought in from the surrounding catchment areas increases turbidity and the thick cover of floating leaf type plant species, allowing very little light to pass through, which are thought to be the main causative agents for the suppression of submerged types, as (Clayworth and Harper,1962) and (Mclay, 1962) concluded. However (Wilson, 1941) and (Vander-Valk and Bliss, 1971; Deepika and Sheikh, 2019) found that the occurrence of *Myriophyllum spicatum* and *Ceratophyllum demersum* as prevalent understory species is likely attributable to their tolerance of low light intensity.

I found twelve species of macrophytes in the Dal Lake in the year 2021. The IVI values of the macrophytes were calculated and the results (aforementioned) were published in Environmental technology and Innovations in the same year. However, I continued to collect information related to the relative frequency, relative density and relative abundance of the macrophyte species in the Dal Lake till 2022 and found total nineteen macrophyte species. The seven other macrophytes which were found were *Phragmites australis*, *Lemna minor*, *Sagitaria latifolia*, *Cyperus sp*., *Carex sp*., *Polygonum amphibium*, and *Nasturtium officinale*. Therefore, in the present thesis the latest IVI values have been reported and discussed.

Table 40. Macrophyte diversity indices during the winter season (Dec.2020 - Nov.2021).

Sites	Shannon Index H	Simpson Index D	Pielou's Evenness J
A	1.24	0.65	0.48
B	0.98	0.51	0.36
C	0.84	0.46	0.37
D	0.90	0.47	0.36

Table 41. Macrophyte diversity indices during the spring season (Dec.2020 - Nov.2021).

Sites	Shannon Index H	Simpson Index D	Pielou's Evenness J
A	1.18	0.60	0.46
B	1.00	0.52	0.36
C	0.91	0.51	0.39
D	1.24	0.63	0.45

Table 42. Macrophyte diversity indices during the summer season (Dec.2020-Nov.2021).

Sites	Shannon Index H	Simpson Index D	Pielou's Evenness J
A	1.25	0.65	0.48
B	1.01	0.52	0.37
C	0.73	0.39	0.31
D	1.24	0.64	0.49

Table 43. Macrophyte diversity indices during the autumn season (Dec.2020-Nov.2021).

Sites	Shannon Index H	Simpson Index D	Pielou's Evenness J
A	1.23	0.64	0.47
B	1.02	0.52	0.37
C	0.71	0.37	0.30
D	1.22	0.63	0.49

The Important value index of macrophytes is tabulated in the (Tables 36-39), where as the diversity indices values of Shannon, Simpson and Pielous evenness are given in the (Table 40-43) (Hoghewey and Brenkert, 1969) reported these results in the aquatic macrophytes of the tropics, (Rai and Munshi,1982) in the emergent macrophytes of India, and (Rather, 2007) in the macrophytes of Kashmir attribute these characteristics to the influence of favorable climatic conditions on the successful growth of macrophytes (Parray et al., 2021). Increased dryness may facilitate the move to pasture grass assemblages, whereas even a slight increase in moisture, especially when combined with increased water levels may result in a change to *Typha* assemblages (Mukherjee et al., 2017). A relatively slight change in average yearly water level could result in a shift in macrophyte community type from native to alien species (Gwin et al., 1999). Water levels that are stable and moderate to deep are more likely to favour a *Typha* monotype (Wetzal and Grace, 1981; Wetzel and Vander Valk, 1998; Houck, 1996).

The estimation of diversity indices of macrophytes reveal that higher values of Shannon index were observed at Hazratbal site (1.25) during the summer season and lowest at the Laam site (0.71) during the autumn season. Where as the values of Simpson index ranged from (0.65) at the Hazratbal site during in summer season and lowest at the Laam site (0.37) during autumn season. The values of Pielou's evenness index revealed that higher values were observed at Brarinambal site (0.49) and lowest at the Laam site (0.30) during autumn (Tables 40-43). The higher values of diversity observed at the given sites are supported by the earlier observations and are mainly determined by sewage and domestic wastes which are released into the Dal Lake and lead to the enhanced growth of macrophytes (Rao et al., 1990). The lower diversity indices values observed at the different sites may be due to low nutrient content at these sites (Nuzhat et al., 2013). The higher evenness index was recorded at the Brarinambal site (0.49) during summer and lowest at the Laam site (0.30) during autumn season. Similar results were observed by (Jahangeer et al., 2021) during their study on the macrophytes of Manasbal Lake, Kashmir.

6.4. Physico-chemical Parameters of Dal Lake

The physico chemical characters of water were analysed on monthaly basis during the year 2020-2021. The water samples were analysed for some important parameters which determine the potability of water and the quantum of pollution, are given here under). In Fig 10- 31, the standard deviation (SD) is added to the bars and the bars that do not share the same superscript are significantly different at $p<0.05$ as indicated by Fisher's LSD test.

Table 44. Seasonal variation in average values of atmospheric temperature (˚C) along the four study stations of Dal Lake during Dec.2020-Nov. 21.

Sites	Seasons			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	9.1 ± 3.25	20.33 ± 4.71	30.56 ± 1.33	22.5 ± 7.54
Habbak	9.13 ± 3.40	20.16 ± 4.66	30.43 ± 1.32	22.36 ± 7.50
Laam	9.13 ± 3.36	20.26 ± 4.45	30.4 ± 1.21	22.33 ± 7.50
Brarinambal	8.96 ± 3.50	19.06 ± 6.62	30.33 ± 1.22	22.26 ±7.53

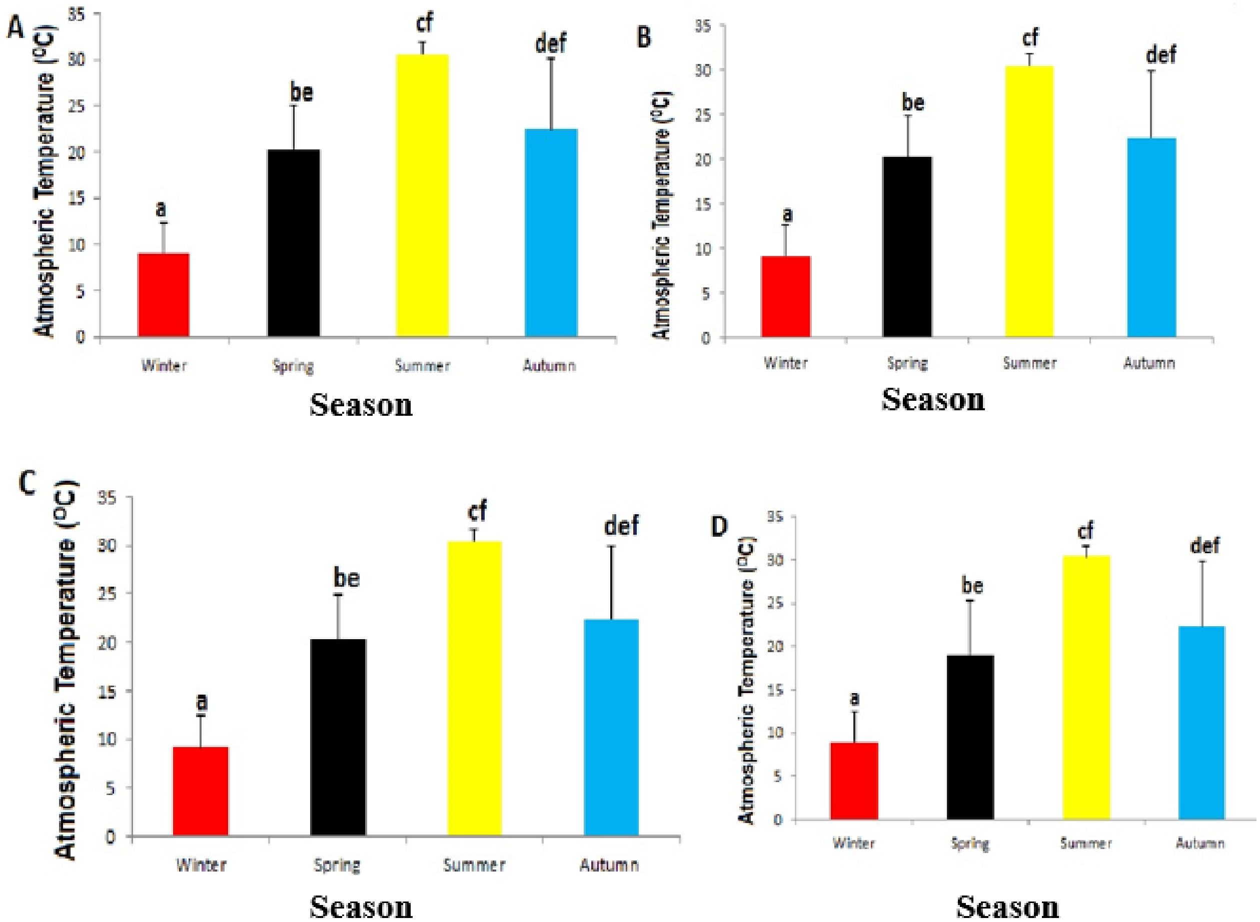


Figure 10. Mean variation in atmospheric temperature (˚C) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Table 45 Variation in average water temperature (°C) at the four sites within the Dal Lake during Dec. 2020-Nov. 21.

Sites	Seasons			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	4.03± 0.75	14.2 ± 4.43	25.83 ± 0.60	18.03 ± 7.73
Habbak	4.46±1.68	14.06 ±4.42	25.76 ± 0.45	17.9 ± 7.69
Laam	4.13± 1.20	14.16 ± 4.42	25.73 ± 0.49	17.8 ± 7.69
Brarinambal	3.69 ± 1.10	14.00 ± 4.47	25.56 ± 0.86	17.83 ± 7.83

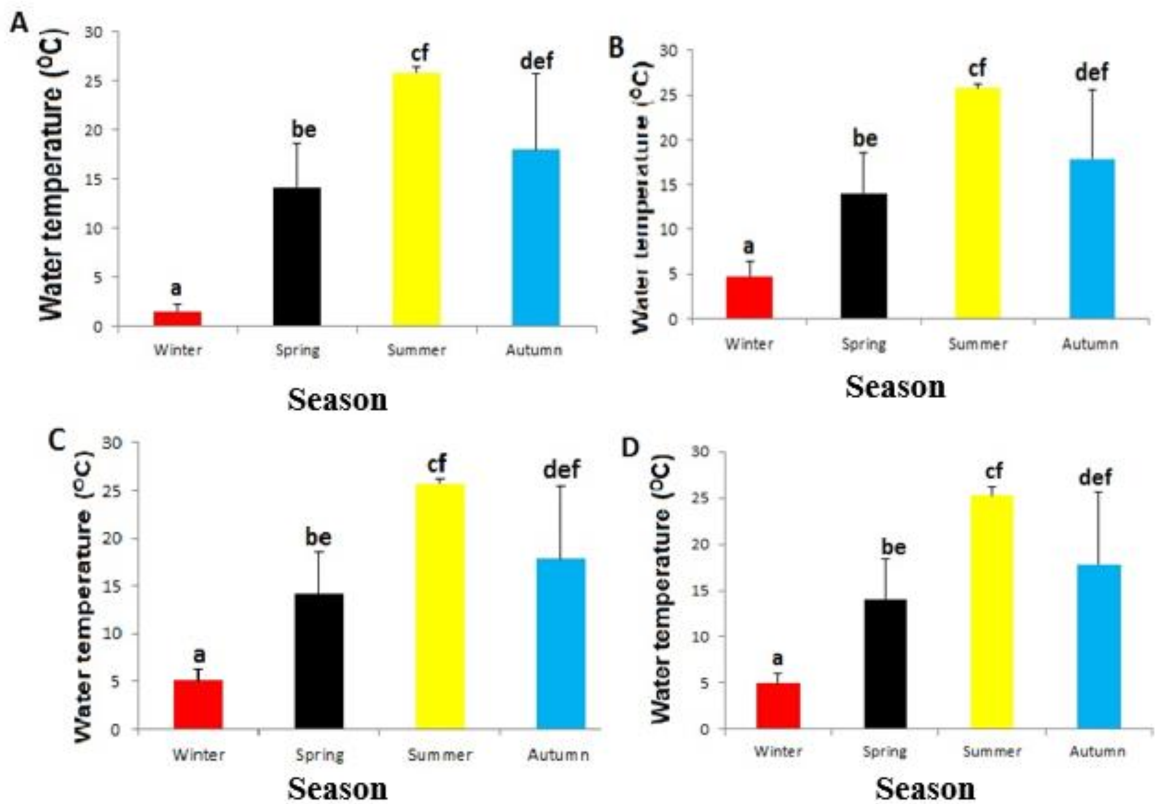


Figure 11. Mean variation in water temperature (°C) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal) within the Dal (2020- 2021).

Changes in atmospheric temperature are in proximity with that of change of seasons and brings about a corresponding change in the temperature of water, The depth of the water body and the macrophytic species growing in the Dal Lake are also controlling factors of water temperature as has also been reported by (Misra et al., 1975). The observed differences in atmospheric and water temperature are due to the winter mixing and high specific heat of water of the lake (Table 44). The steep rise in temperature during summer season results in the accelerated decay of organic matter and the increased liberation of carbon dioxide. The water bodies which are smaller in area react very sharply to the changing temperatures (Welch, 1952; Zubair and Ahrar, 2013). Increased temperature leads to reduction in the solubility of gases with in the water body (Table 44, 45). Colour of the waters is mainly due to some metallic ions such as iron and manganese which prevents the light penetration thereby interfering with the photosynthetic process of planktons.

Table 46 Variation in average pH at the four sites within the Dal Lake during Dec 2020-Nov 21.

Sites	Seasons			
	Winter (Mean±SD	Spring Mean±SD	Summer Mean±SD	Autumn Mean±SD
Hazratbal	7.43 ± 0.11	7.4 ± 0.20	7.23 ± 0.20	7.56± 0.21
Habbak	7.43 ± 0.25	7.53 ± 0.25	7.2 ± 0.10	7.53 ± 0.15
Laam	7.46 ± 0.15	7.5 ± 0.26	7.33 ± 0.15	7.46 ± 0.15
Brarinambal	7.26 ± 0.15	7.36 ± 0.11	7.3 ± 0.10	7.36 ± 0.20

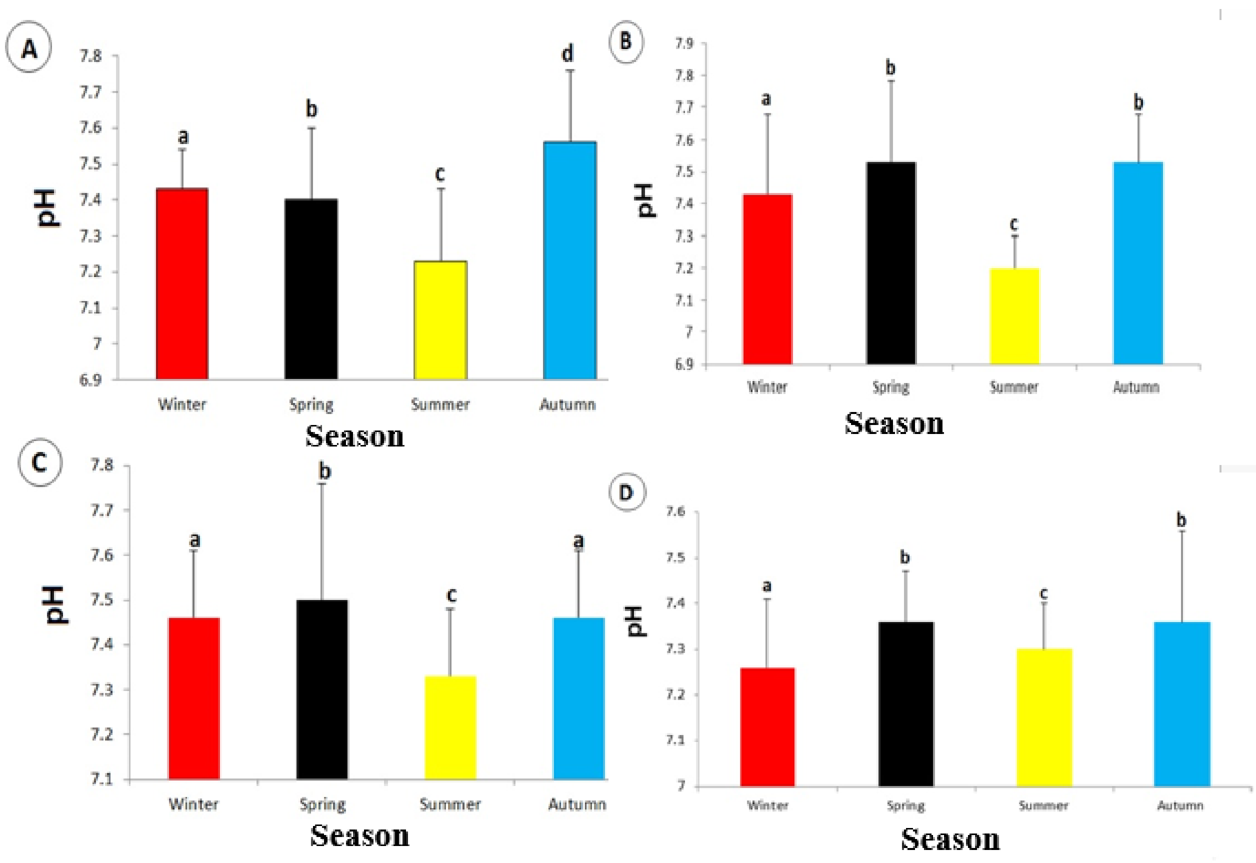


Figure 12. Mean variation in average pH at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

pH is a very important parameter in determining the water quality and is a measure of acidity and alkalinity (Kishe, 2004). Higher pH in water causes bitter taste thus causing the decrease in the disinfection capacity of chlorine as a consequence higher dose of chlorine needs to be added (Araoye, 2009). Low pH of water leads to the dissolution of metals and other substances. Higher pH of the Lake was recorded at around 7.5 during autumn at the Habbak site of the Dal Lake (Table 46). High pH around the lake was due to excessive use of carbon dioxide by phytoplankton growth, besides discharge of agricultural wastes (Saleem and Jeelani, 2016).

Table 47 Variation in free carbon dioxide (mg/l) at the four sites within the Dal Lake during Dec 2020- Nov 21.

Sites	**Seasons**			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	1.03 ± 0.58	0.9±0.10	2.26 ± 1.28	1.43 ± 0.11
Habbak	1.03± 0.66	0.86±0.05	2.4 ± 1.27	1.56 ± 1.52
Laam	1.03± 0.49	0.76±0.05	2.26± 1.23	1.5± 0.10
Brarinambal	0.8 ± 1.52	0.8±0.6	2.1± 1.24	1.3± 0.10

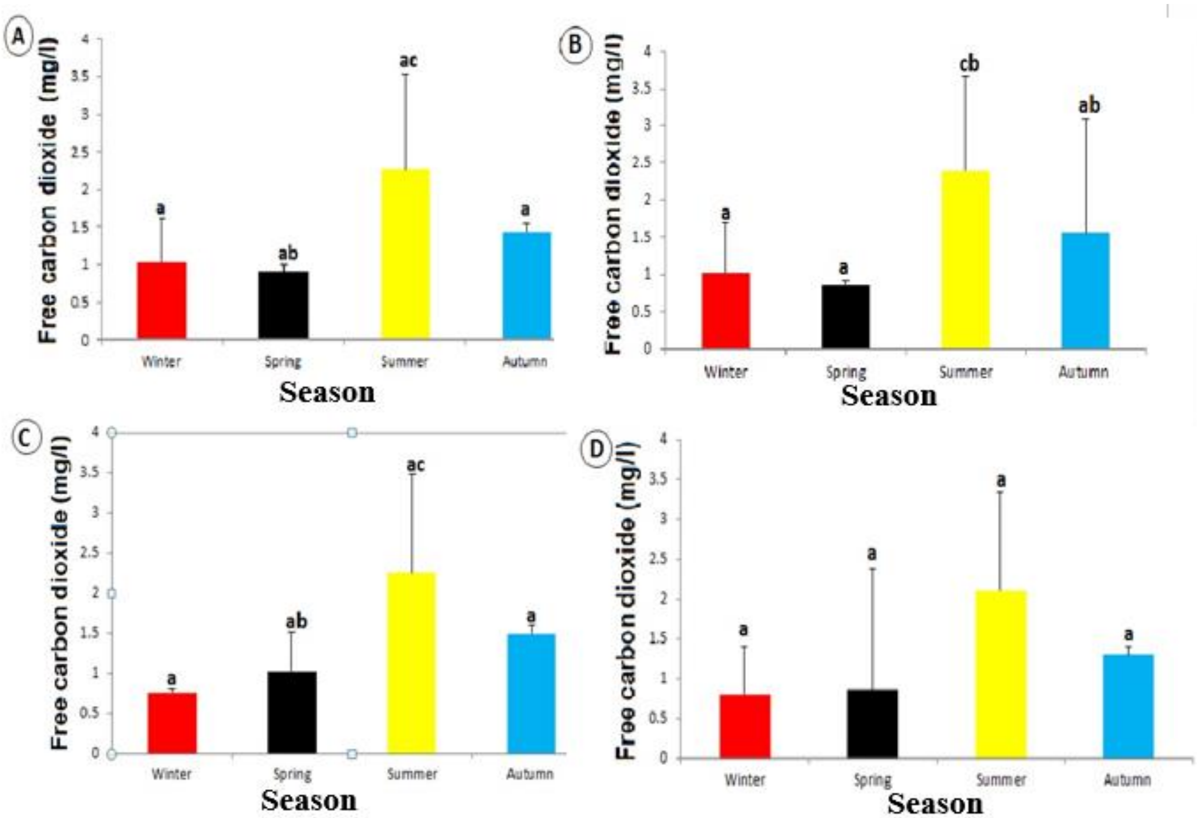


Figure 13. Mean Variation in free carbon dioxide (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Table 48 Variation in bicarbonates (mg/l) at the four sites within the Dal Lake during Dec 2020- Nov 21.

Sites	Seasons			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	66.9 ± 6.45	65.86 ±0.40	64.56 ± 1.67	56.3 ± 3.17
Habbak	66.96± 3.18	66.46 ±0.40	64.76 ± 1.67	56.53 ± 3.09
Laam	67.03 ± 1.60	65.63± 1.47	64.53±1.81	56.4 ± 3.10
Brarinambal	66.73± 6.42	72.5 ± 0.30	64.63 ± 1.53	56.2±3.04

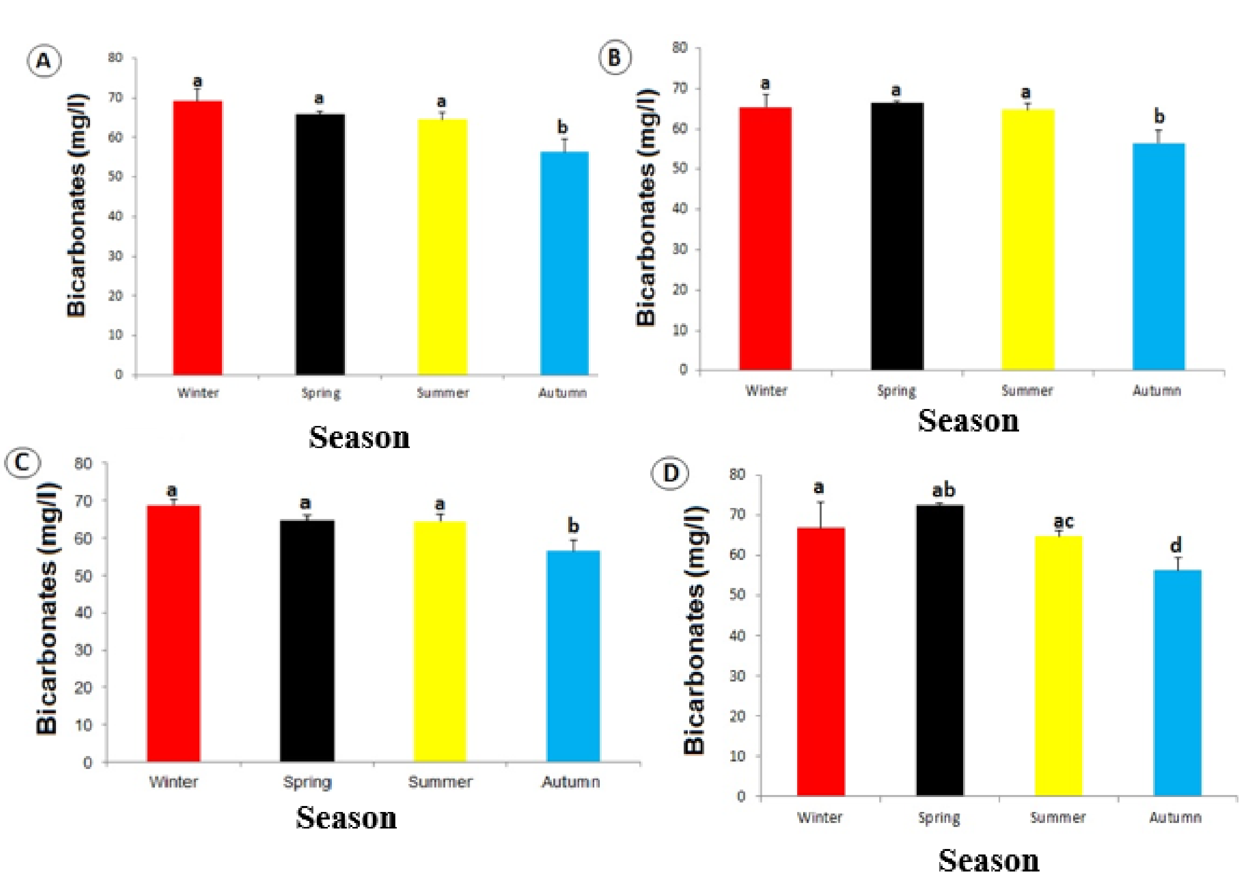


Figure 14. Mean Variation in bicarbonates (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

The values of bicarbonates ranged from 56 to 72 mg/L and an average of 65 mg/L. The highest concentration was found in Brarinambal site (Table 47, 48). The lowest concentration of carbonate in the autumn was mainly due to its dissolution (Saleem and Jeelani, 2016).

Table 49 Variation in alkalinity (mg/l) at the four sites within the Dal Lake during Dec 2020- Nov 21.

Sites	Seasons			
	Winter (Mean±SD)	Spring (Mean±SD)	Summer (Mean±SD)	Autumn (Mean±SD)
Hazratbal	182.86 ± 3.87	176.06±0.68	197.76±5.15	182.2 ±2.69
Habbak	176.23± 1.63	174.71±1.38	196.6±3.18	180.86 ±3.13
Laam	179.5± 2.34	174.99±0.21	194.86±3.71	180.46 ± .83
Brarinambal	177.3± 2.20	175.26±5.24	287.63±5.61	179.36 ±1.15

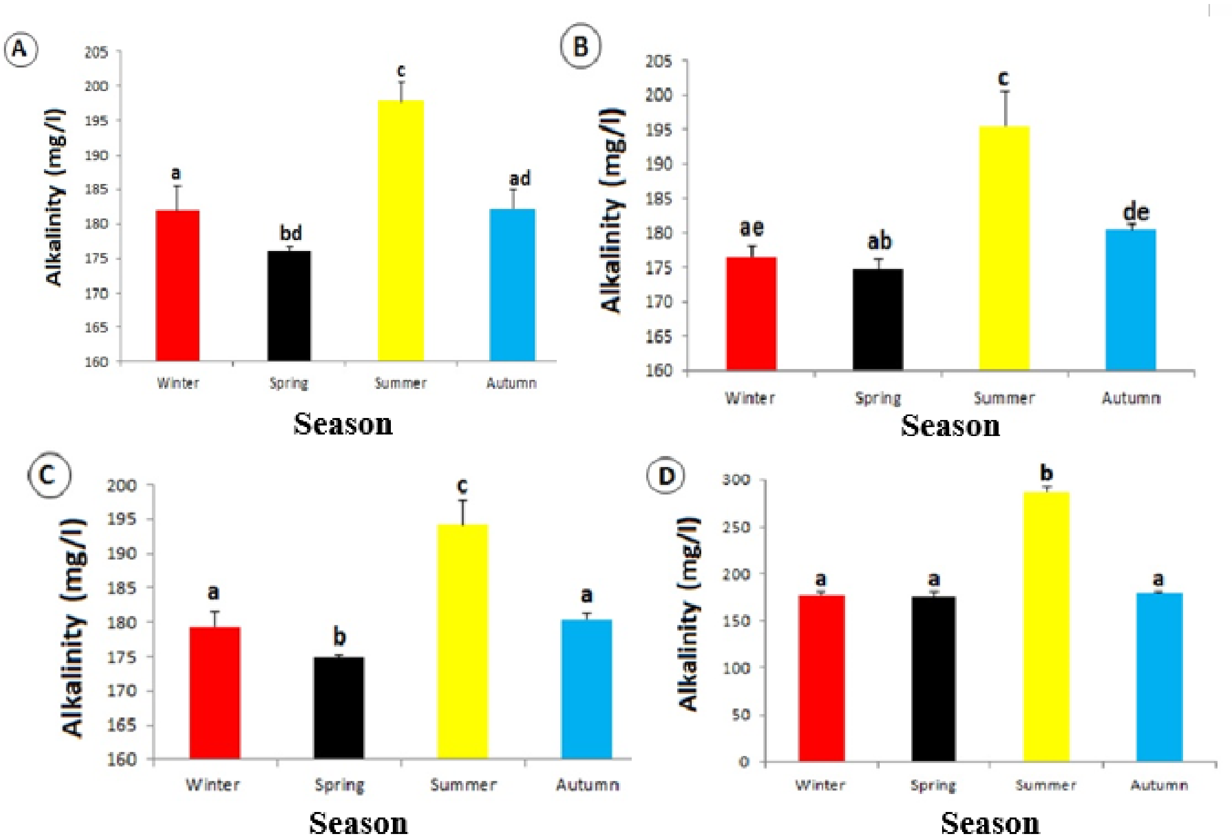


Figure 15. Mean Variationin alkalinity (mg/l) (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Alkalinity of water is mainly governed by the weak acids and their balance by the cations against them (Jhingran, 1978). It plays a dominant role in controlling the enzymatic activity. The alkalinity of higher productive waters remains with in the range of 100 ppm (APHA, 1985). In the present study the values of alkalinity ranged between 287 to 180 mg/L during summer and autumn (Table 49). Alkalinity concentrations are affected by rainfall and the values are lower post monsoon season (Khajuria, 1992). Higher values of alkalinity are due to free hydroxyl ions and dissolution of carbon dioxide in water.

Table 50 Variation in dissolved oxygen (mg/l) at the four sites within the Dal ake during Dec 2020- Nov 21.

Sites	Seasons			
	Winter (Mean±SD)	Spring (Mean±SD)	Summer (Mean±SD)	Autumn (Mean±SD)
Hazratbal	5.63 ± 0.15	5.43± 0.15	4.83 ± 0.35	5.6±0.10
Habbak	6.2 ± 0.62	6.13 ± 0.15	5.46 ± 0.70	5.43 ± 0.15
Laam	6.1 ± 0.62	6.5 ± 0.26	5.43 ± 0.85	5.4 ± 0.10
Brarinambal	5.96 ± 0.68	5.96 ± 0.30	5.26 ± 0.75	5.26 ± 0.05

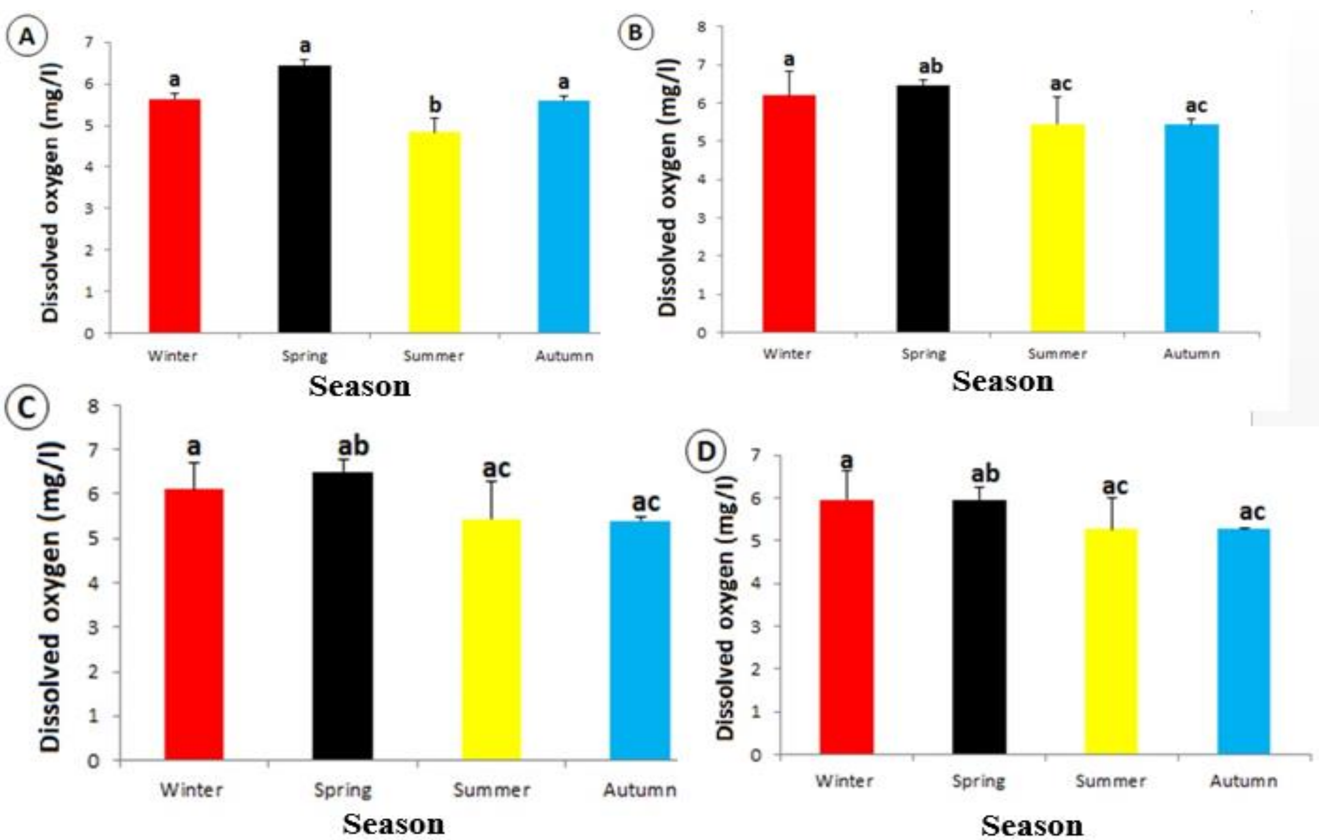


Figure 16. Mean Variation in dissolved oxygen (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021). Standard deviation (SD) is added to the bars and the bars that do not share the same superscript are significantly different at *p<0.05* as indicated by Fisher's LSD test

Dissolved oxygen is one of the most important parameters for determining the water quality. The DO concentrations in water are mainly due to the photosynthetic activity and diffusion of oxygen from air. The oxygen concentration in water due to flux from air will depend on their solubility and are influenced by factors like water movement and temperature, while photosynthetic component is determined by the autotrophic activity with in the lake (Table 50). The values of dissolved oxygen below 5 ppm are unsuitable for fish production (Kudesia,1980). The values of dissolved oxygen are generally decreased due to pollution load of water bodies which otherwise remain saturated with dissolved oxygen. Dissolved oxygen has a direct relationship with carbonates, bicarbonates and magnesium hardness. DO concentration in water is in direct relationship with solubility and lower the DO value lower is the water quality (Zutshi and Vaas, 1978). During the present study the values of DO range between 4.83 to 6.2 mg/L respectively at the Hazratbal and Habbak site of the Dal Lake. Dissolved oxygen is positively related with BOD (Zuber, 2007).

Table 51 Variation in BOD (mg/l) at the four sites within the Dal Lake during Dec 2020-Nov 21.

Sites	**Seasons**			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	29.83 ± 1.06	31.13 ± 0.92	30.7 ± 0.10	29.26 ± 0.41
Habbak	26.43 ± 0.30	25.73 ± 0.15	24.4 ± 0.26	25.53±0.30
Laam	28.1± 0.52	28.33± 0.40	29.26± 0.15	25.4± 0.10
Brarinambal	29.13± 0.64	29.6± 0.10	29.43± 0.15	28.93 ± 0.49

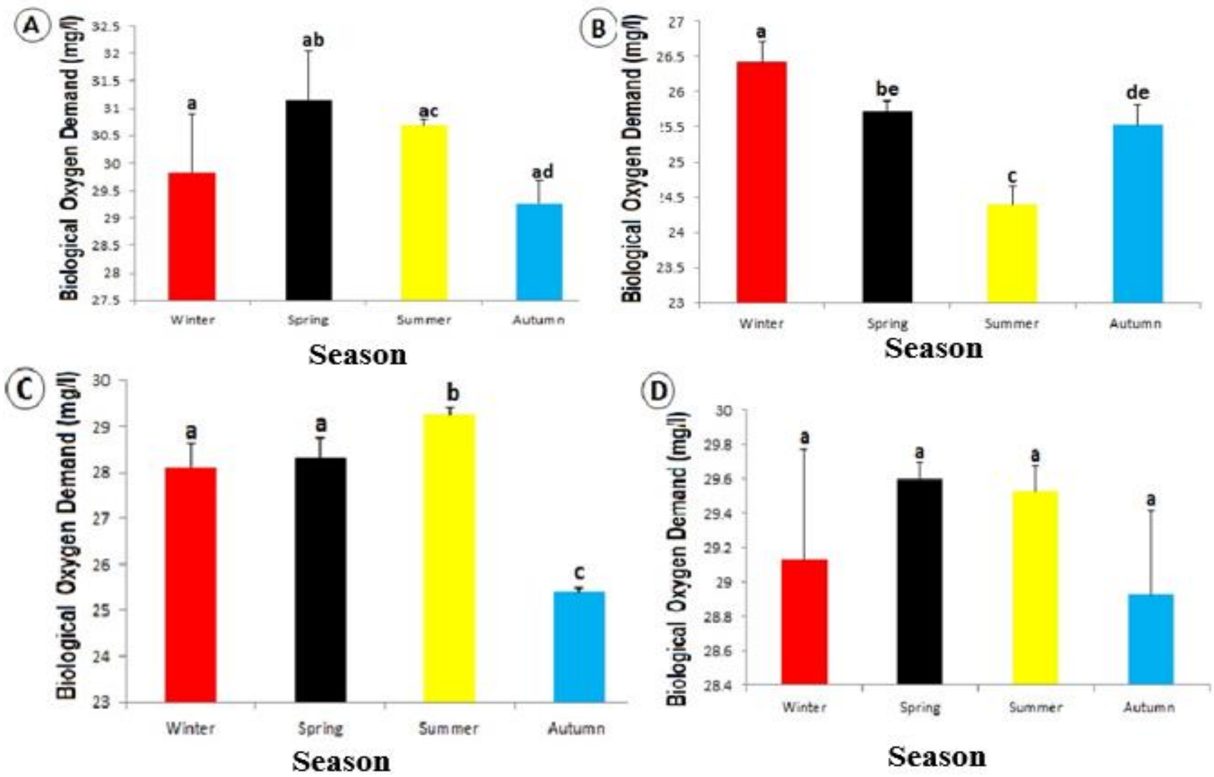


Figure 17. Mean variation in BOD (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Table 52: Variation in COD (mg/l) at the four sites within the Dal Lake during Dec 2020-Nov 21.

Sites	Seasons			
	Winter (Mean±SD)	Spring (Mean±SD)	Summer (Mean±SD)	Autumn (Mean±SD)
Hazratbal	75.73 ± 1.10	75.53 ± 0.30	76.43±0.35	74.26±0.58
Habbak	53.16±1.18	53.2±0.40	54.43±0.25	52.86±0.70
Laam	51.53±0.30	51.3 ± 0.30	52.43± 0.15	51.53± 0.32
Brarinambal	63.58± 0.17	64.2± 0.40	64.93± 0.25	63.8 ± 0.10

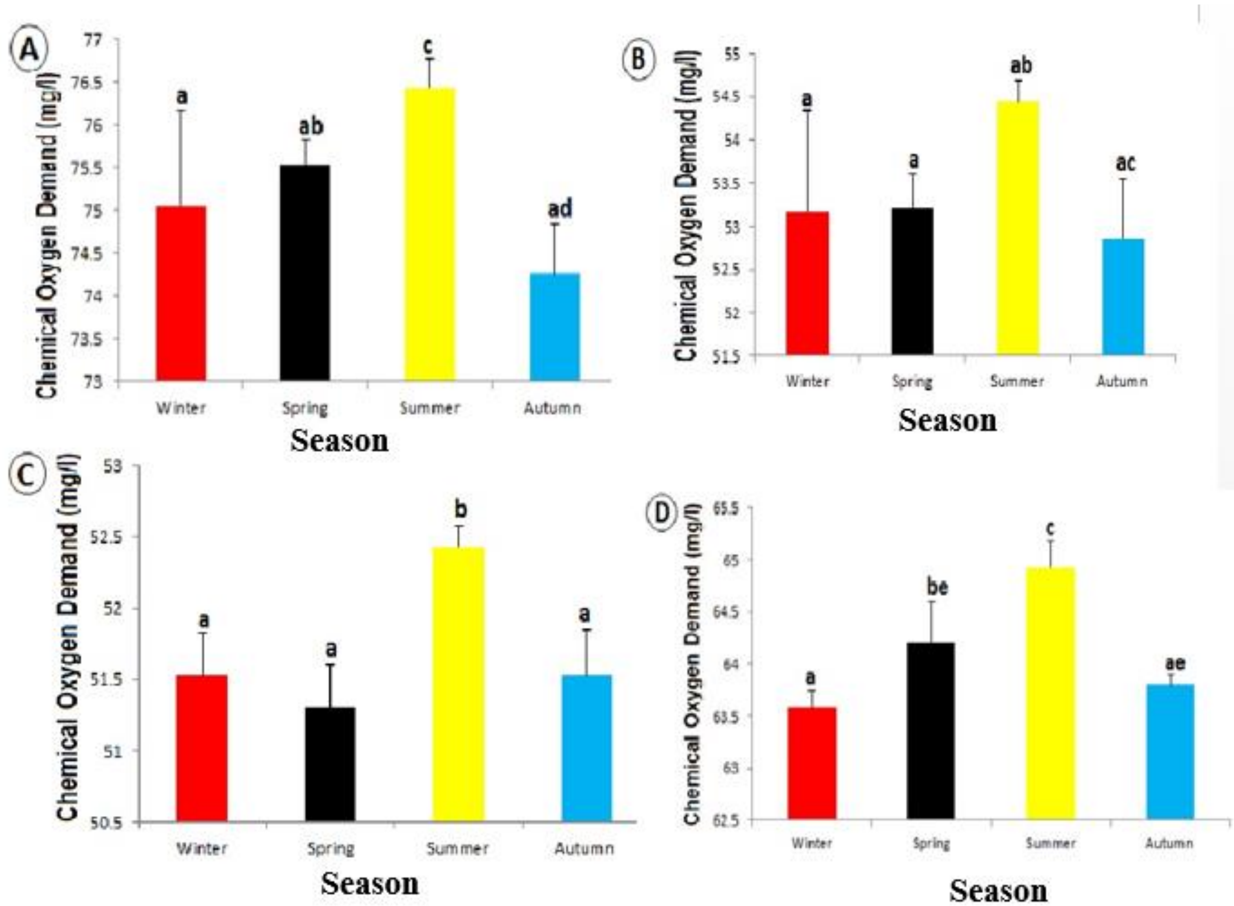


Figure 18. Mean variation in COD (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Biological oxygen demand (BOD) is an important test in determining the pollution level of the water body and is measured as the quantity of oxygen required to stabilize the organic matter. The Lakes and streams having BOD greater than 10mg/L are classified as highly polluted (Nanda and Tiwari, 2002). Higher values of BOD are indicative of the higher organic waste to be degraded (Nudds, 2002). During the present study the values of BOD ranged from 25.5 to 31.1mg/L at the Habbak and Hazratbal sites respectively (Table 51). For drinking purposes, the biological oxygen demand should be with in the range of 3 ppm according to CPCB, New Delhi. BOD of 6ppm is the minimum limit of pollution (WHO, 1982). Chemical oxygen demand (COD) also indicates the level of pollution in the water body. The desired levels of

COD in drinking and irrigation waters are in the range of 20 and 150 mg/L (WHO, 2006). The higher values of COD are due to higher concentration of dissolved solids (Table 52). During the present study the values of COD ranged between 51.5 to 76.4 mg/L at the Laam and Hazratbal site of the lake during winter and summer respectively.

Table 53 Variation in Chlorides (mg/l) at the four sites within the Dal Lake during Dec 2020- Nov 21.

Sites	Seasons			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	12.16 ± 0.63	11.3 ± 0.36	12.13 ± 0.81	11.96 ±0.45
Habbak	11.1 ± 0.79	11.5 ± 0.20	11.5 ± 0.40	10.4 ± 0.10
Laam	10.6 ± 0.43	10.5 ± 0.26	10.43 ±0.15	10.2 ± 0.10
Brarinambal	11.23 ± 0.81	11.46 ± 0.20	11.56 ± 0.30	10.33 ± 0.32

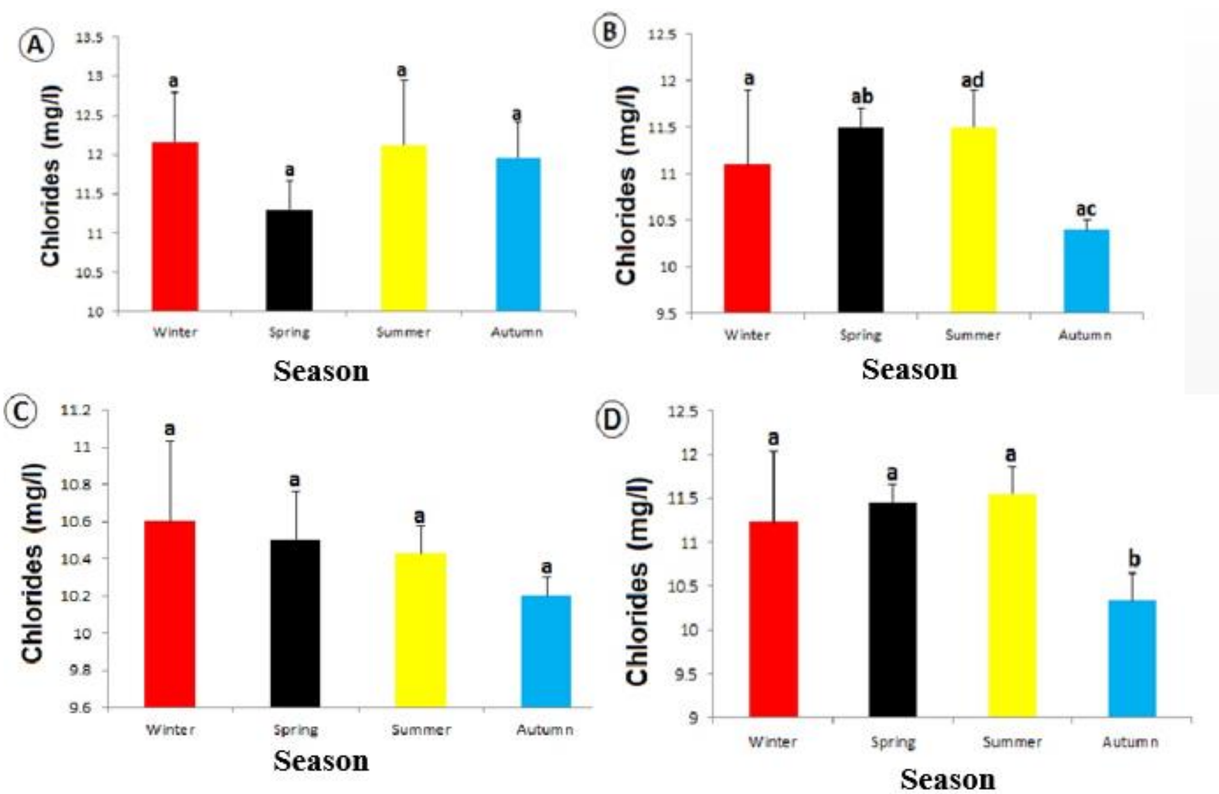


Figure 19. Mean Variation in Chlorides (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Chlorides in water result from combination of chlorine gas and metal, common among them are sodium chloride and magnesium chloride. Sodium chloride is an important constituent in performing basic life processes needed in small amounts, however the sodium part of NaCl is associated with heart and kidney ailments. They are an important constituent in finding out the atmospheric input to the Lakes (Saini et al., 2008; Saleem et al., 2015). The range of chlorides in lakes is around 2 to 17 mg/L and during the present study the chlorides ranged between 10.2 to 12.16 at the Laam and Hazratbal sites of the Dal Lake respectively (Table 53).

Table 54 Variation in calcium (mg/l) at the four sites within the Dal Lake during Dec **2020-Nov 21.**

Sites	Seasons			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	22.83± 0.49	23.2 ± 0.55	21.33 ± 1.92	24.3 ± 3.45
Habbak	22.03 ± 0.60	23.13 ± 0.40	21.66 ± 1.76	24.13 ± 3.43
Laam	21.13 ± 0.66	20.56 ± 0.15	20.03 ±0.37	22.9 ± 3.13
Brarinambal	21.86 ± 0.50	22.36 ± 0.45	20.6 ± 2.36	23.3± 2.84

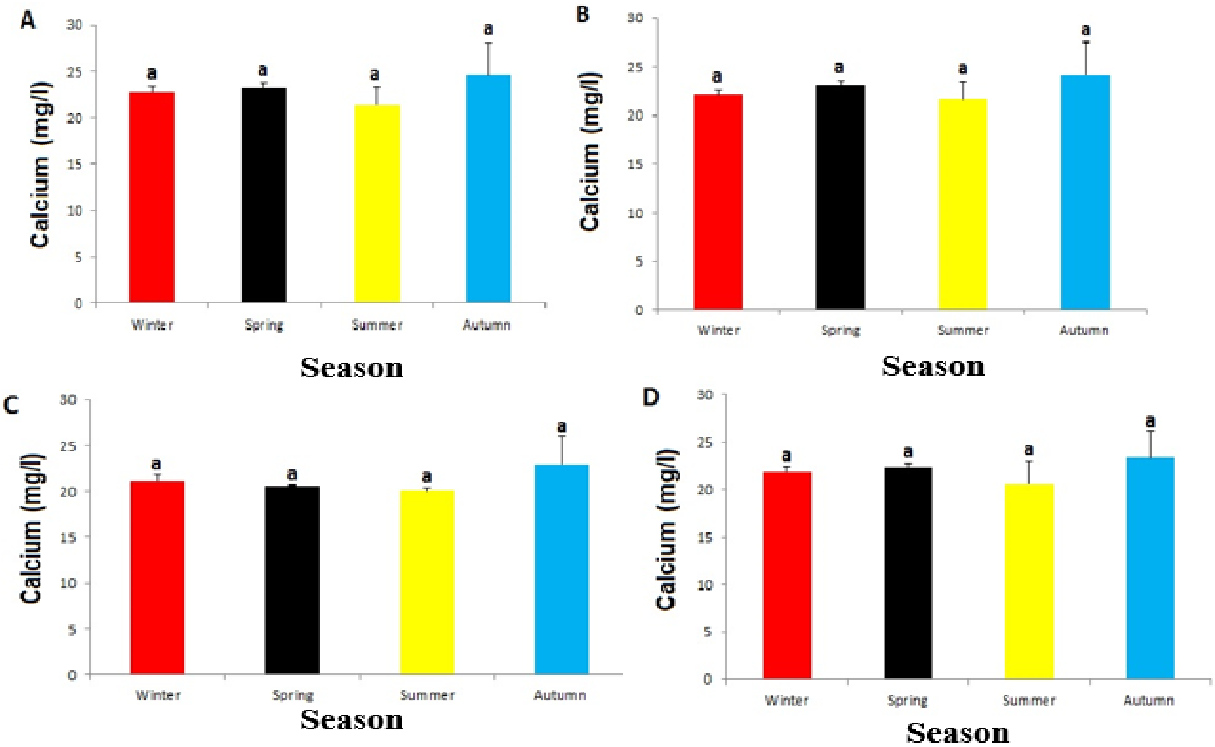


Figure 20. Mean Variation in Calcium (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Table 55 Variation in magnesium (mg/l) at the four sites within the Dal Lake during Dec **2020-Nov 21.**

Sites	**Seasons**			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	3.3± 0.45	2.63 ± 0.15	3.00 ± 0.36	2.9 ± 0.62
Habbak	3.06 ± 0.51	2.46 ± 0.15	2.76 ± 0.35	2.8 ± 0.60
Laam	2.93± 0.56	2.76± 0.35	3.03 ± 0.72	2.6 ± 0.62
Brarinambal	3.2 ± 0.45	2.7 ± 0.20	2.83 ± 0.35	2.8± 0.62

Calcium is an important driver of physiological activity in plant and animal life and is derived from calcium rich rocks (Ghose and Sharma, 1989). Calcium together with magnesium are mainly responsible for hardness of water (Table 54). The most abundant cation present in the range of 20 to 24.1 mg/L in the Dal Lake waters during summer and autumn at the Laam and Habbak sites respectively. Due to dilution effect the values of calcium drop down during summers.

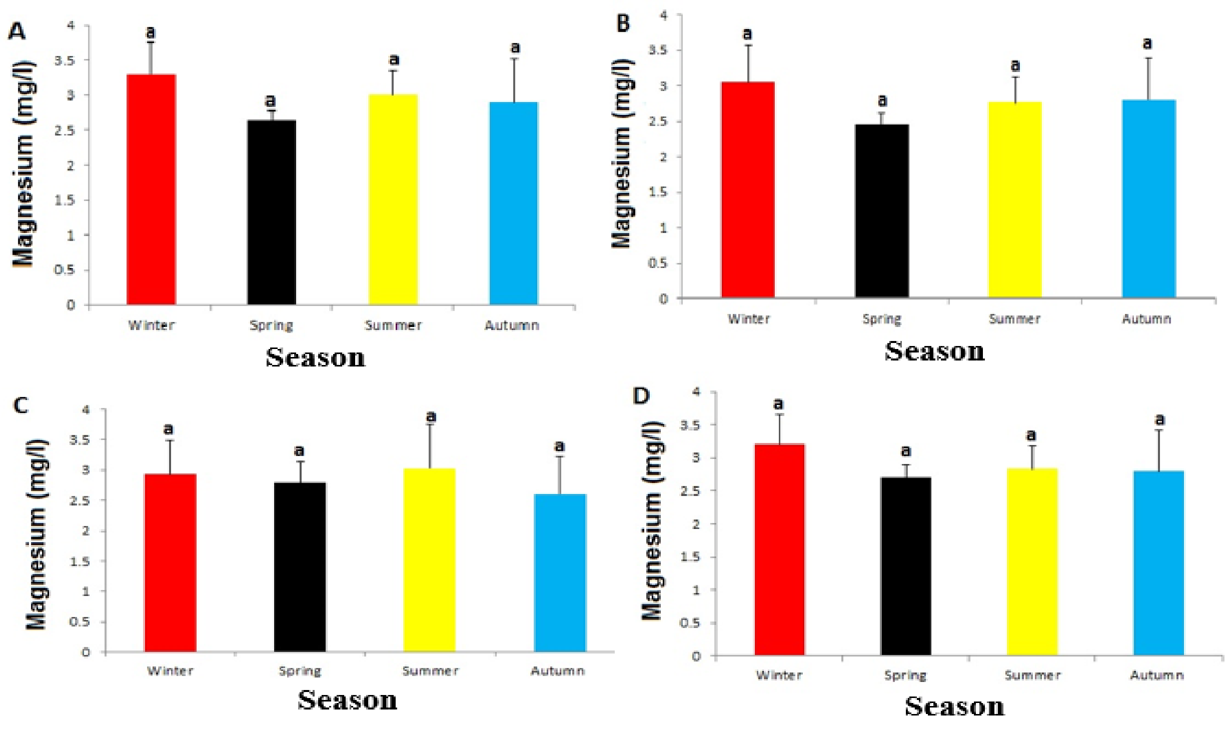


Figure 21. Mean Variation in magnesium (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Magnesium also arises due to weathering of carbonate rocks. It is an important component of chlorophyll in plants responsible for performing photosynthesis and an ingredient of some organometallic compounds. The values of magnesium ranged from 2.4 to 3.3 mg/L in Habbak and Hazratbal sites during spring and winter seasons respectively (Table 55). The concentration of magnesium depends on exchange equilibrium and presence of sodium. Higher concentrations have been found to be diuretic (Sharma, 1999).

Table 56 Variation in total hardness (mg/l) at the four sites within the Dal Lake during Dec 2020-Nov 2021.

Sites	Seasons			
	Winter (Mean±SD)	Spring (Mean±SD)	Summer (Mean±SD)	Autumn (Mean±SD)
Hazratbal	123.46 ± 1.18	125.26 ± 0.45	125.33 ± 0.41	124.3 ± 0.95
Habbak	123.16 ±1.18	123.26 ± 0.41	122.96 ± 0.50	122.63 ± 0.20
Laam	122.10 ± 0.78	123.13 ± 0.45	122.66 ± 0.23	121.36 ± 0.57
Brarinambal	123.36 ± 0.75	123.83 ± 0.35	123.16 ± 0.40	122.7± 0.10

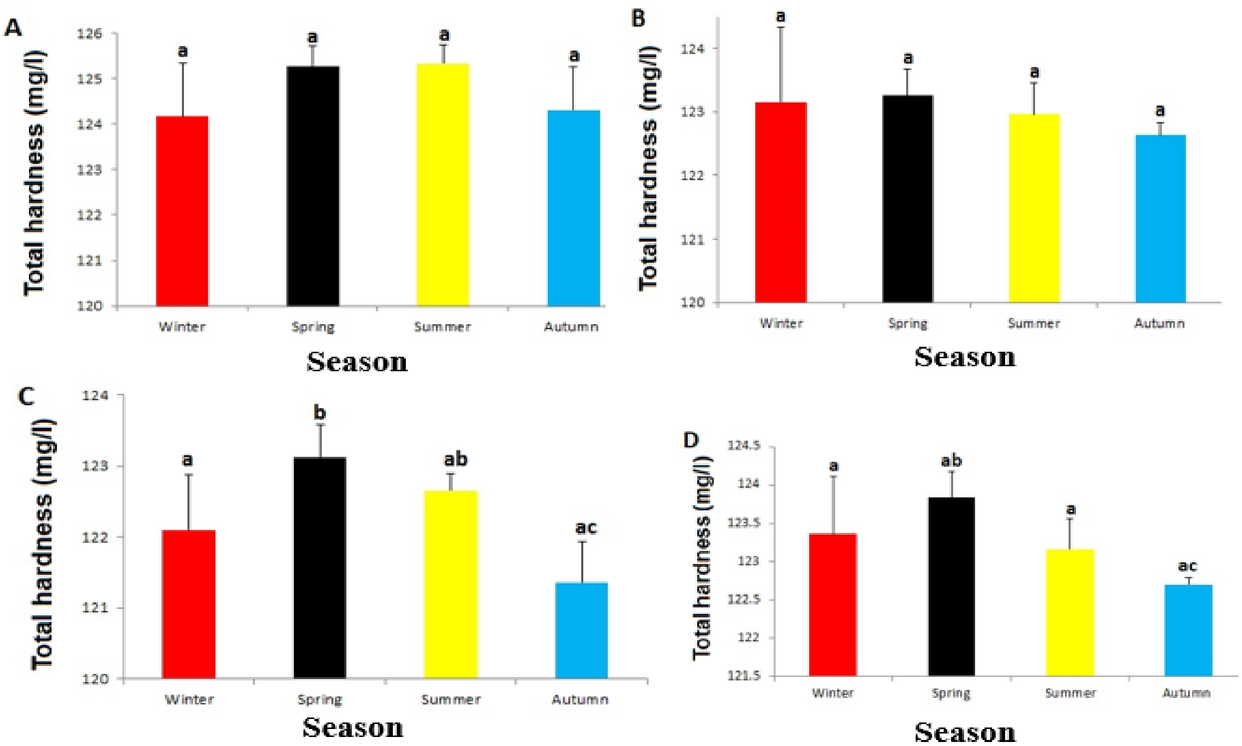


Figure 22. Mean variation in total hardness (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Hardness is determined by the calcium and magnesium salts together with carbonates and bicarbonates. The Lakes with hardness greater than 64mg/L are considered as hard waters. Due to bathing and washing activities carried on the banks of Dal Lake hardness of water increases. Due to evaporation the hardness of water increases and the higher levels were observed during summer 125.3 at the Hazratbal site and lower 121.3 at the Laam site of the Lake (Table 56), similar results were observed by (Kataria, 1994 and Saxena,1998).

Table 57 Variation in conductivity (µS) at the four sites within the Dal Lake during Dec 2020- Nov 2021.

Sites	Seasons			
	Winter (Mean±SD)	Spring (Mean±SD)	Summer (Mean±SD)	Autumn (Mean±SD)
Hazratbal	160 ± 4.16	185.66 ± 0.57	194.53 ± 2.57	168.33 ± 3.60
Habbak	152.66 ±7.50	176.63 ± 0.35	159.9 ± 4.53	162.66 ± 6.02
Laam	209.8 ± 3.51	210.73 ± 0.25	212.26 ± 3.98	158.33 ± 5.50
Brarinambal	228.00 ± 2.64	228.36 ± 0.40	238.56 ± 3.38	228.83 ± 3.05

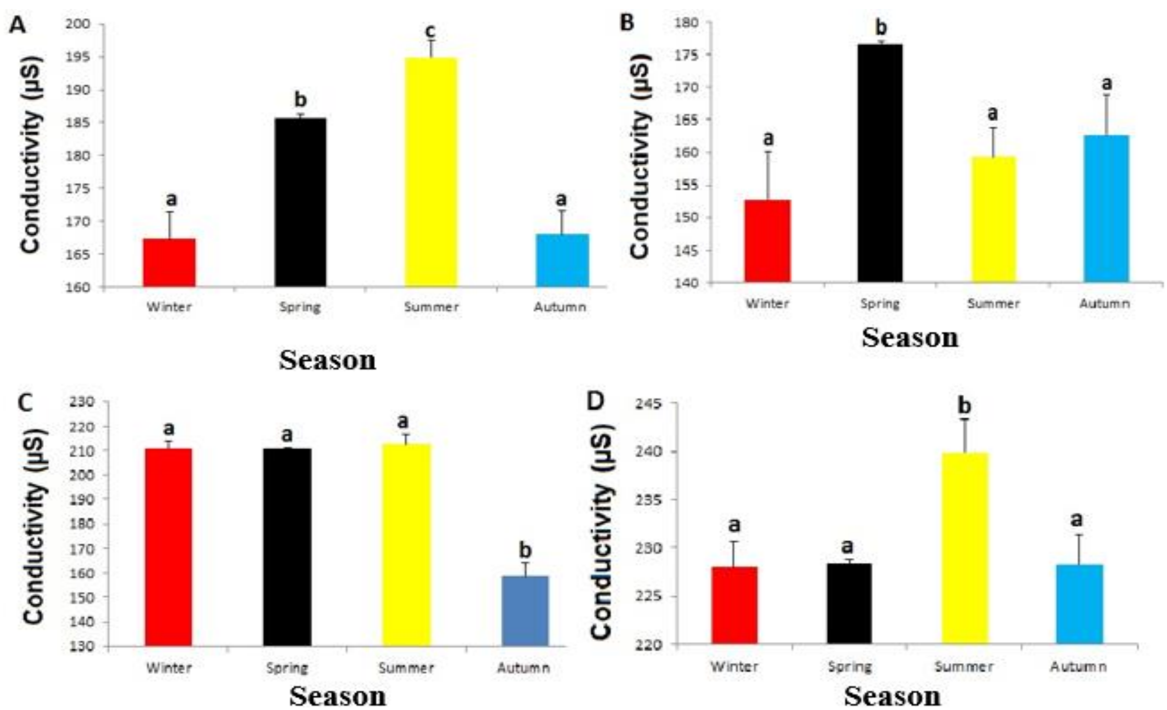


Figure 23. Mean variation in conductivity at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020-2021).

Total salt content of the sample is a measure of electric conductivity and is measured by the flow of electric current through the sample. Pure water has low electric conductivity because of low number of electrolytes and higher in case of polluted water. It has been found to increase with increase in number of ions. During the present study higher, electrical conductivity was observed at Brarinambal site which was 238.5 µS/ cm during summer season and lowest at the 152.6 µS/ cm at the Habbak site of Dal Lake (Table 57). Similar results were observed by (Shastree et al., 1991).

Table 58 Variation in total dissolved salts (mg/l) at the four sites with in the Dal Lake during Dec 2020-Nov 21.

Sites	Seasons			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	108.96 ± 3.63	128.13 ± 0.30	176.26 ± 4.25	156.53 ± 4.50
Habbak	108.73 ± 6.52	121.16 ± 0.55	142.26 ± 8.64	141.46 ± 1.76
Laam	166.06 ± 4.35	157.23 ± 0.45	178.9 ± 4.59	178.1 ± 1.22
Brarinambal	109.2 ± 3.59	107.46 ± 0.58	139.7 ± 2.51	124.63 ± 5.15

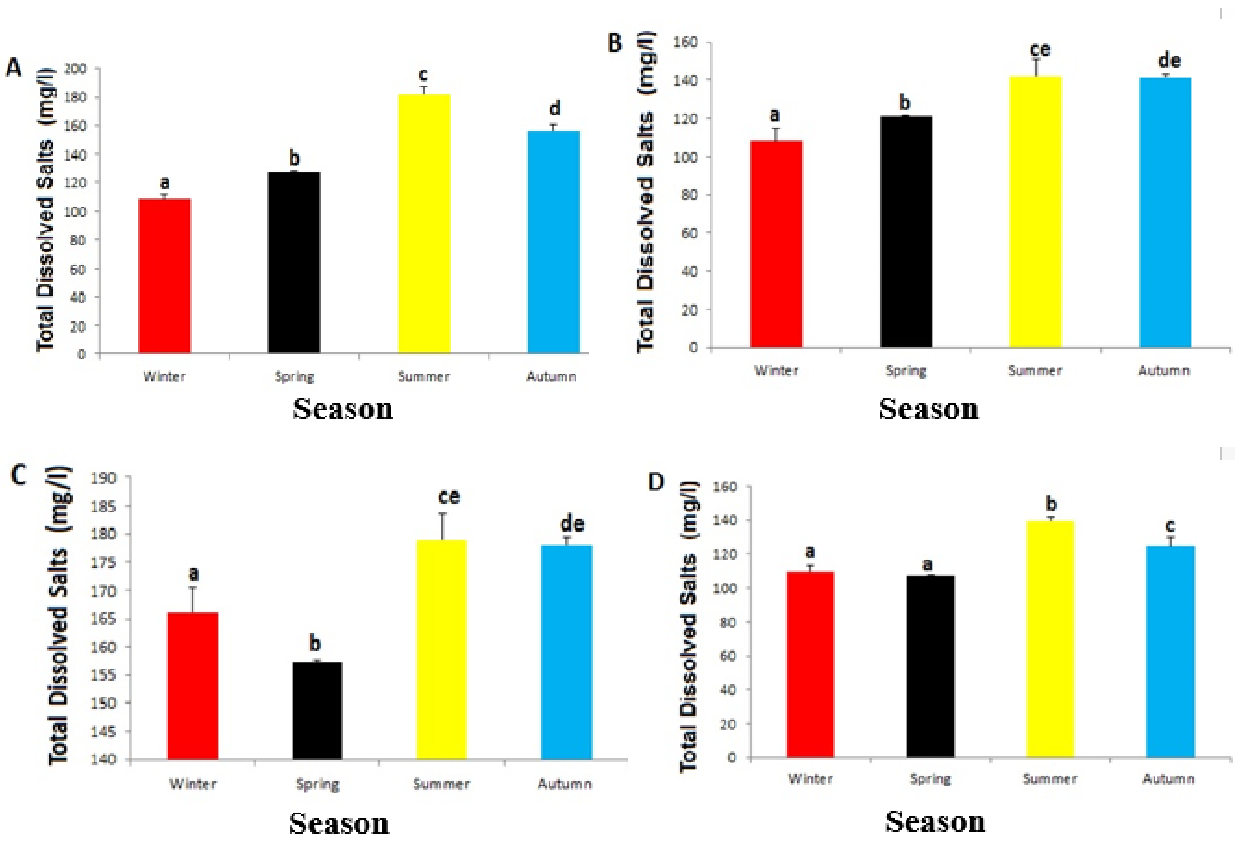


Figure 24. Mean Variation in total dissolved salts (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020-2021).

Total dissolved solids are estimated by the weight of residue left when the sample is completely evaporated (WHO, 2006). The main components of TDS are (Cl^+, Mg^+, Na^+ Cl^-, HCO_3^- and SO_4^{2-}). The higher values of TDS were reported as 178.9 mg/L at the Laam site and lower at the 107.46 mg/L at the Brarinambal site of Dal Lake respectively (Table 58). Similar results were reported by (Sabata and Nayar, 1995) in Brahmaputra River.

Sulphates are found naturally in some minerals including barite and gypsum (Fisher and Mullican, 1997). They are generally released into the water by the industrial operations that use H_2SO_4 such as mining and paper mills. Higher levels of sulphates were recorded at the Hazratbal site 34.6 mg/L in spring and lower concentration at Laam site 12.4 mg/L (Table 59). Higher concentration of sulphates was found to be due to the presence of restaurants, houseboats and floating gardens with in the Dal Lake where excessive use of fertilizers is being done. Similar results were observed by (Saleem and Jeelani, 2016).

Table 59 Variation in sulphate (mg/l) at the four sites with in the Dal Lake during Dec 2020-Nov 2021.

Sites	Seasons			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	20.66 ± 3.21	34.66 ± 0.57	20.26 ± 1.10	25.00 ± 2.64
Habbak	17.00 ± 2.64	14.53 ± 0.47	13.53 ± 2.15	17.0 ± 3.05
Laam	15.33 ± 3.05	12.4 ± 0.45	12.46 ± 1.28	14.6 ± 5.00
Brarinambal	26.33 ± 3.51	22.33 ± 0.30	19.2 ± 1.58	20.33 ± 5.13

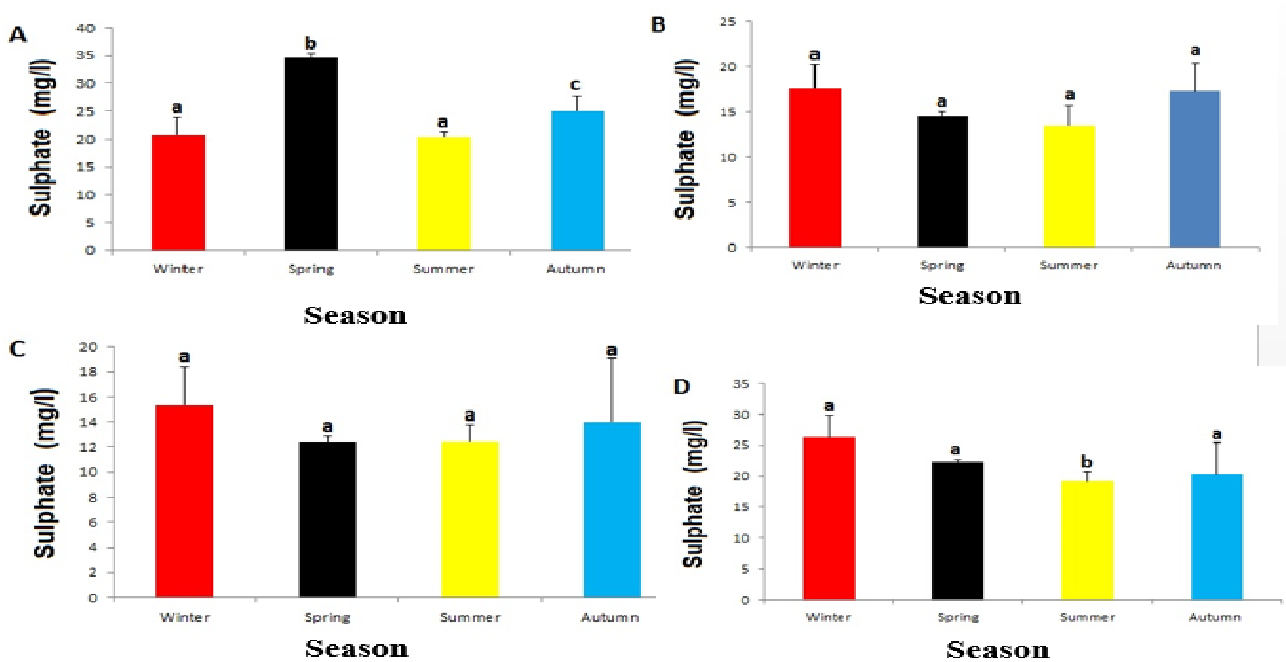


Figure 25. Mean variation in sulphate (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Table 60 Variation in sodium (mg/l) at the four sites within the Dal Lake during
Dec **2020-Nov 21.**

Sites	Seasons			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	2.6 ± 0.80	1.5 ± 0.10	1.63 ± 0.75	4.7 ± 1.04
Habbak	1.86 ±1.26	1.46 ± 0.32	2.0 ± 0.70	4.76 ± 1.70
Laam	1.83 ±0.83	1.56 ± 0.15	1.66 ± 0.56	4.06 ± 2.46
Brarinambal	2.6± 1.11	1.2 ± 0.10	1.4± 0.60	3.83 ± 1.83

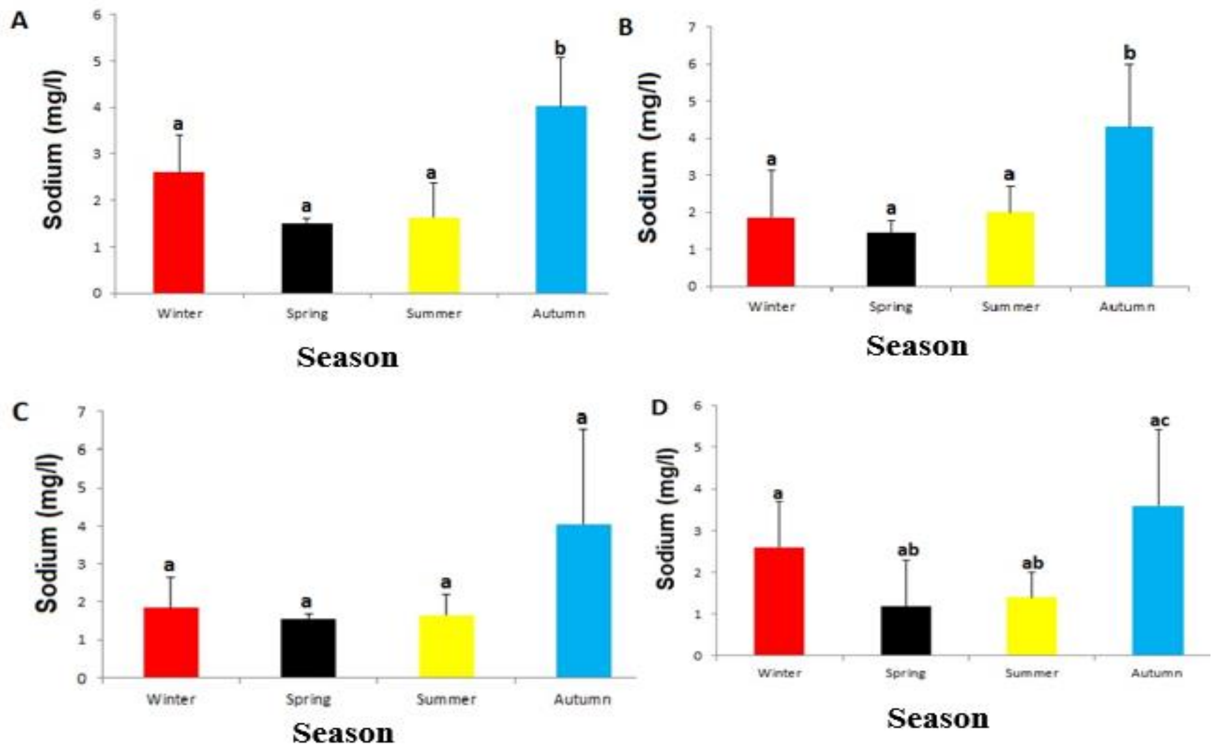


Figure 26. Mean Variation in sodium (mg/l**)** at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Rock weathering is the primary source of sodium in water besides some sewage and industrial wastes which add up to the increased sodium concentration in water. In natural waters atmospheric precipitation, and silicate minerals are the major contributors (Valiente and Avendanao, 1993). During the current study the values of sodium fluctuated from 1.2 mg/L at brarinambal to 4.7 mg/L at the Habbak site of the Lake (Table 60). The higher values of sodium at the Hazratbal site could possibly due to the large habitation and the large number of food outlets because of Hazratbal shrine, and the lower values due to bioaccumulation. According to NAS (1977) higher doses of sodium are causing cardiac disorders.

Table 61 Variation in potassium (mg/l) at the four sites with in the Dal Lake during Dec 2020-Nov 21.

Sites	Seasons			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	4.53 ± 1.46	2.2 ± 0.10	0.86 ± 0.30	1.0 ± 0.26
Habbak	4.23 ±0.98	2.06 ± 0.57	1.33 ± 0.25	1.2 ± 0.70
Laam	3.90 ± 1.41	1.6 ± 0.10	1.13 ± 0.32	1.23 ± 0.81
Brarinambal	4.0± 1.75	1.26 ± 0.05	1.0 ± 0.70	1.83 ± 0.51

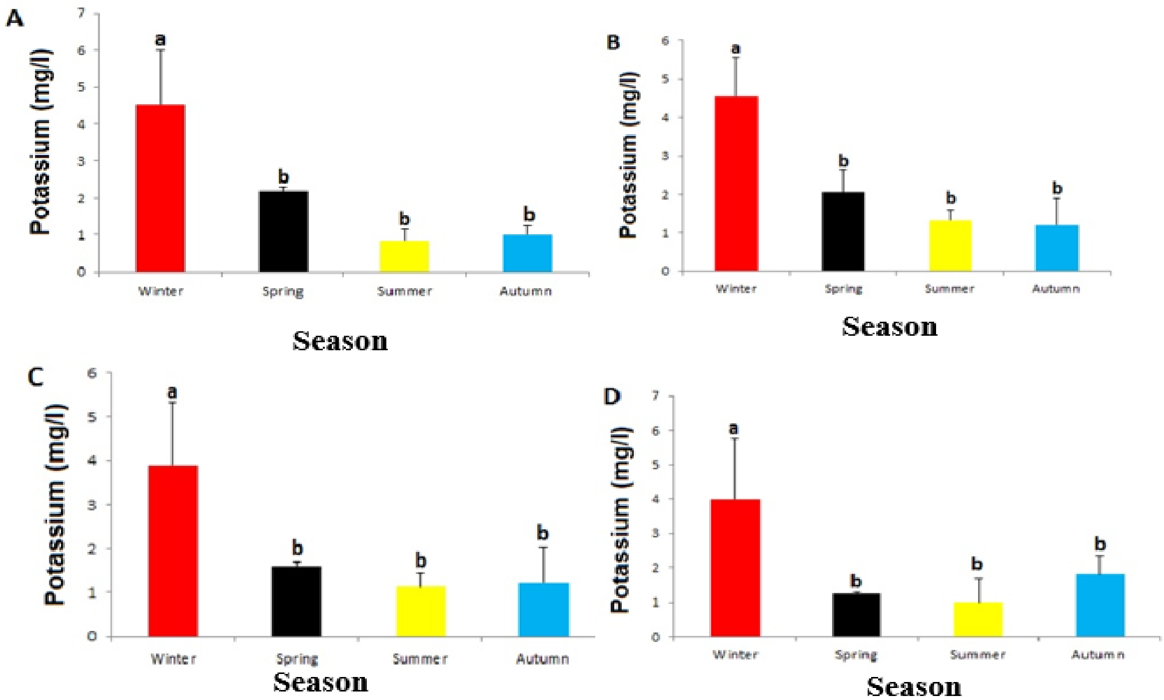


Figure 27. Mean Variation in potassium (mg/l**)** at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

The primary source of potassium again is the weathering of rocks but the lower values of potassium compared to sodium is the resistance of potassium containing rocks to weathering (WHO, 2006). However, they do enter the water bodies because of agricultural activity and surface run off. During the current study, the values of potassium ranged from 0.8 mg/L during summer at Hazratbal to 4.5 mg/L at Hazratbal site during winter (Table 61).

Table 62 Variation in fluoride (mg/l) at the four sites within the Dal Lake during Dec 2020-Nov21.

Sites	Seasons			
	Winter (Mean±SD)	Spring (Mean±SD)	Summer (Mean±SD)	Autumn (Mean±SD)
Hazratbal	0.02 ± 0.02	0.03 ± 0.10	0.04 ± 0.02	0.06 ± 0.01
Habbak	0.05 ±0.02	0.16 ± 0.11	0.03 ± 0.11	0.05 ± 0.03
Laam	0.05 ±0.02	0.01 ± 0.00	0.04 ± 0.03	0.03 ± 0.02
Brarinambal	0.05± 0.03	0.05 ± 0.01	0.02 ± 0.02	0.03 ± 0.02

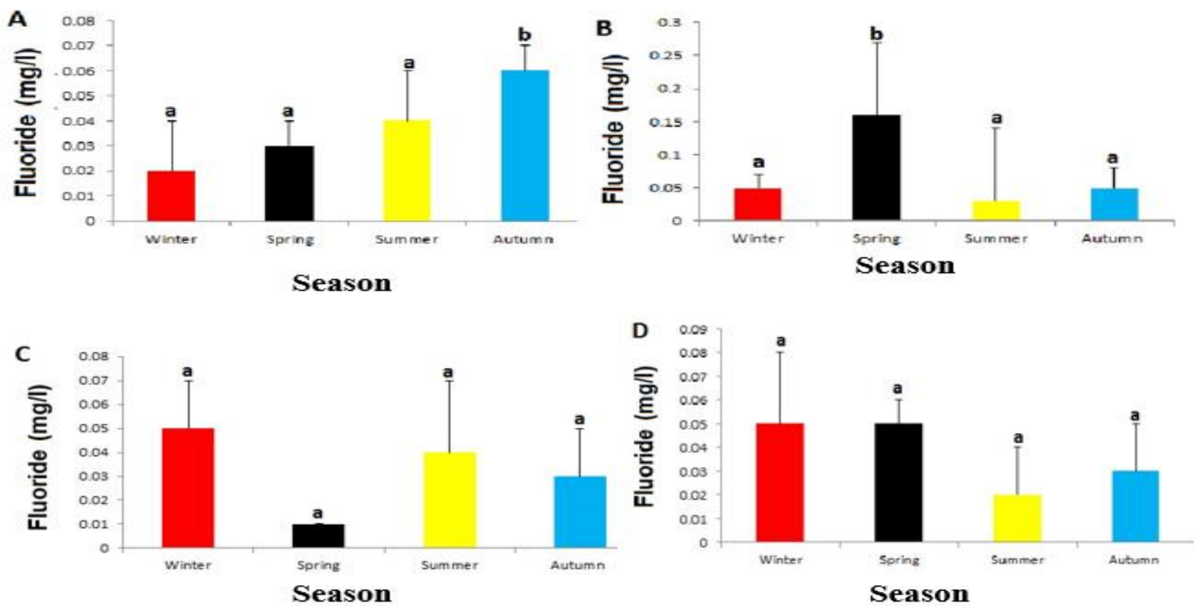


Figure 28. Mean variation in fluoride (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Fluorides are the significant pollutants and have the tremendous potential to cause ecological disaster (Marier, 1972). Though they are needed for the skeletal development (WHO, 2002), but higher concentrations are thought to increase the requirement for calcium and magnesium intake (Rose and Marier, 1977). Deficiency of fluorides cause fluorosis (IPCS, 2002).

Table 63 Variation in nitrate nitrogen (mg/l) at the four sites within the Dal Lake during Dec 2020-Nov 21.

Sites	Seasons			
	Winter (Mean±SD)	Spring (Mean±SD)	Summer (Mean±SD)	Autumn (Mean±SD)
Hazratbal	0.86 ± 0.00	0.85 ± 0.00	0.86 ± 0.03	0.86 ± 0.00
Habbak	0.78 ± 0.00	0.78± 0.00	0.78 ± 0.00	0.78 ± 0.00
Laam	0.42 ±0.00	0.43 ± 0.00	0.43 ± 0.00	0.43 ± 0.00
Brarinambal	0.45 ± 0.10	0.46 ± 0.00	0.46 ± 0.00	0.46 ± 0.00

During the current study the higher levels of fluoride was recorded at the Hazratbal site 0.06 mg/L and lower at the Laam site 0.01 mg/L (Table 62). The higher fluoride content in the water body can be due to geothermal activity as has been observed by (Zuber, 2007).

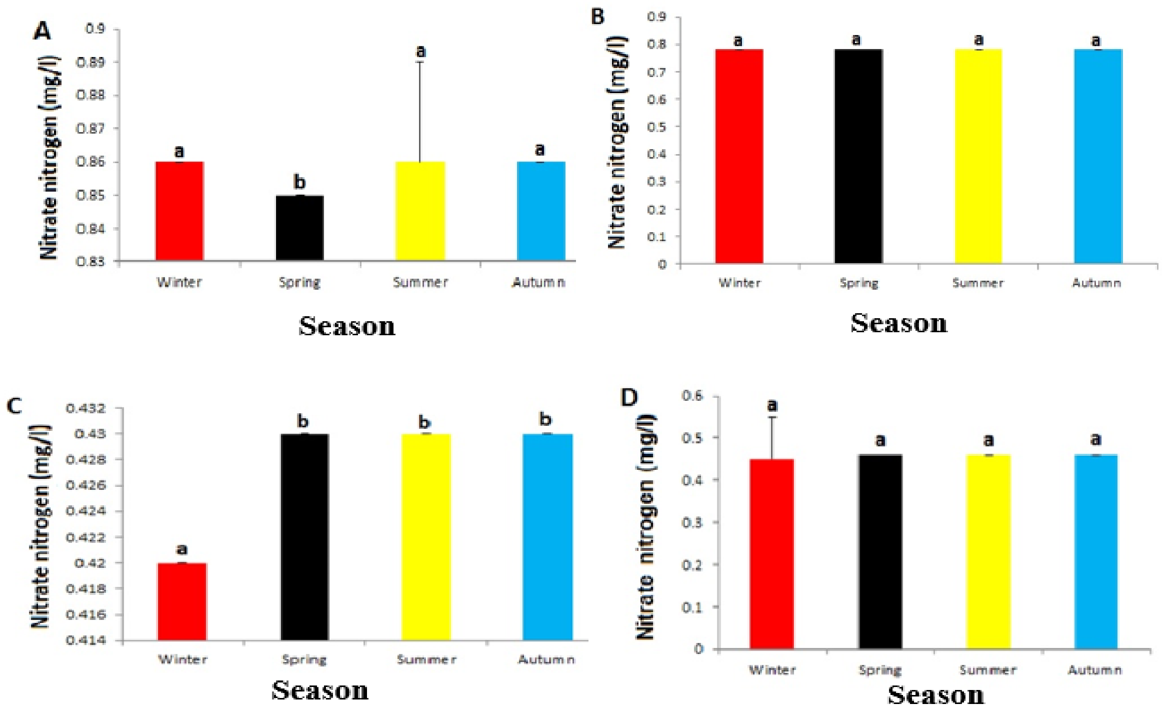


Figure 29. Mean variation in nitrate nitrogen (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020-2021).

For performing the successful growth certain nutrients are essentially needed (Zhenzhen et al., 2015; He, 2002). Though nutrients are essential for plant growth however their excessive concentrations have serious ramifications of eutrophication mainly caused by nitrates and phosphates (Table 61) (Parray and Koul, 2021). Due to the arrival of migrant birds from siberia and other countries the ammoniacal nitrogen content increases in the water bodies (Table 64). This nutrient enrichment is detrimental to the very essence of the Lake (Qin and Zhu, 2005; Zhenzhen et al., 2015). The nitrate content in the water body is increased due to use of fertilizers in the vicinity of the Dal Lake and within the floating gardens of the water body for cultivation of vegetables besides decomposition process occurring within the lake and flushing of latrines located in the houseboats of the Dal Lake. During the present study the higher values of nitrate were recorded at the Hazratbal site of the Lake 0.86 mg/L and the lower values were observed at the Laam site of the Lake 0.42 mg/L during winter (Table 63). The higher values of nitrate could be due to the surface run off of sewage and municipal wastes from the catchment of the Lake (Dar et al., 2017).

Table 64 Variation in ammonical nitrogen (mg/l) at the four sites within the Dal Lake during Dec 2020-Nov21.

Sites	Seasons			
	Winter (Mean±SD)	**Spring (Mean±SD)**	**Summer (Mean±SD)**	**Autumn (Mean±SD)**
Hazratbal	0.13 ± 0.00	0.22 ± 0.00	0.23 ± 0.00	0.16 ± 0.03
Habbak	0.15 ± 0.05	0.12± 0.00	0.19 ± 0.00	0.18 ± 0.04
Laam	0.16 ±0.01	0.16 ± 0.00	0.15 ± 0.00	0.15 ± 0.01
Brarinambal	0.13 ± 0.10	0.14 ± 0.00	0.15 ± 0.00	0.14 ± 0.01

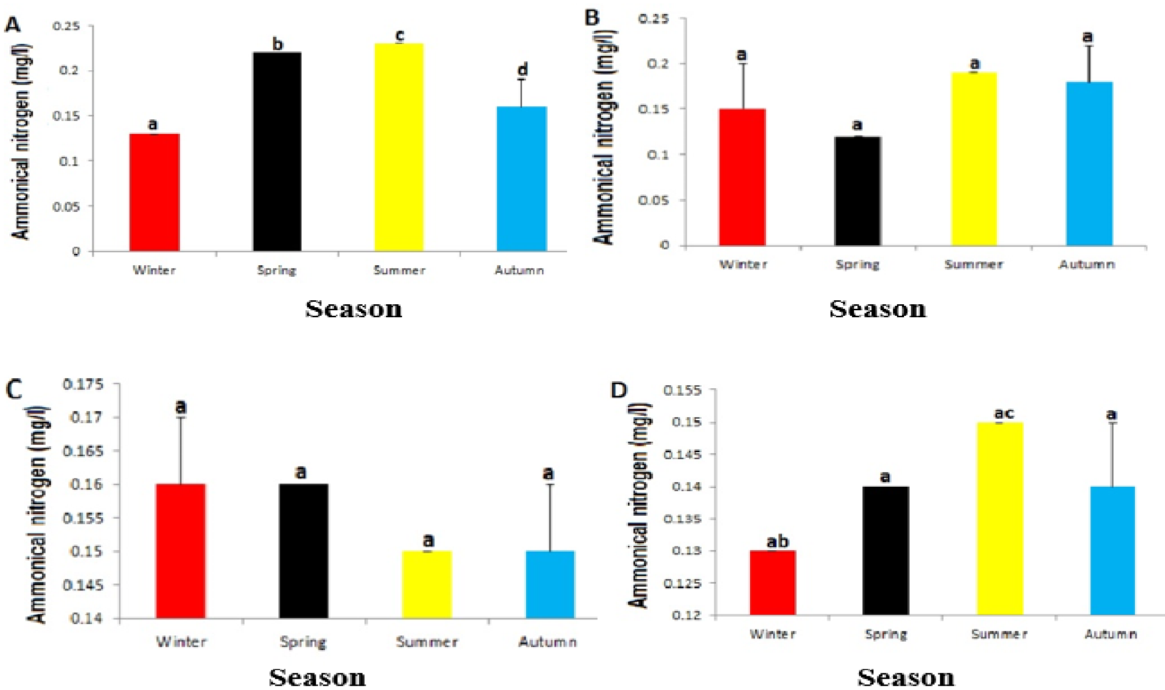


Figure 30. Mean variation in ammonical nitrogen (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

Table 65 Variation in orthophosphate (mg/l) at the four sites with in the Dal Lake during Dec 2020-Nov21.

Sites	Seasons			
	Winter (Mean±SD)	Spring (Mean±SD)	Summer (Mean±SD)	Autumn (Mean±SD)
Hazratbal	0.13 ± 0.13	0.20 ± 0.00	0.13 ± 0.06	0.08 ± 0.04
Habbak	0.06 ± 0.04	0.20± 0.00	0.20 ± 0.02	0.08 ± 0.02
Laam	0.11 ±0.07	0.18 ± 0.00	0.19 ± 0.02	0.10 ± 0.08
Brarinambal	0.08 ± 0.04	0.19 ± 0.00	0.17 ± 0.02	0.11 ± 0.08

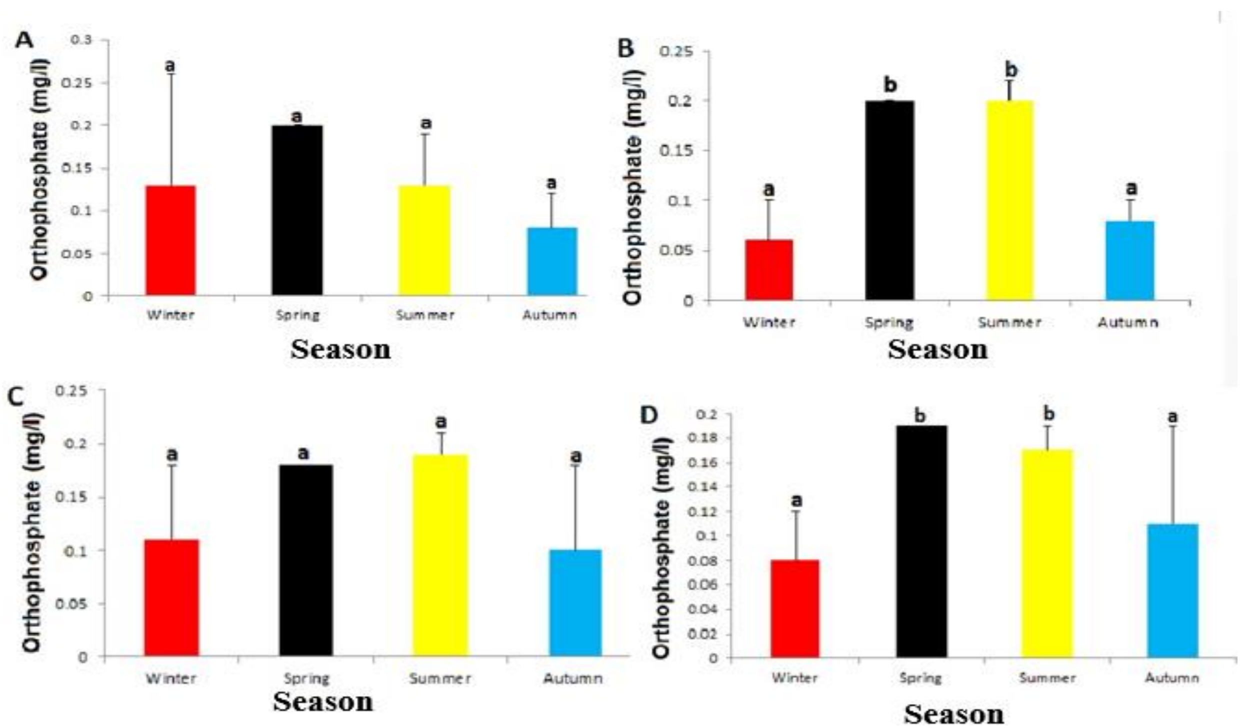


Figure 31. Mean variation in orthophosphate (mg/l) at the four sites **(A)**: Hazratbal; **(B)**: Habbak; **(C)**: Laam; **(D)**: Brarinambal within the Dal (2020- 2021).

6.5. Heavy metal estimation of Dal Lake.

The Phosphorus is an essential nutrient for performing the day-to-day biochemical processes and a component of nucleic acids and enzymatic reactions (Wetzel, 2001). The main sources of phosphorus being ground water, precipitation and household waste discharge and leaching from sedimentary rocks (Lal, 1998; Jordan and Weller, 1996). Increased phosphate concentration above 0.2 mg/L causes eutrophication (Iqbal and Kataria, 1995). In the rainy season the phosphorus leached from the agricultural fields enters into water body causing eutrophication (Skaggs et al., 1994). During the current study the higher levels of phosphate was recorded at Hazratbal site during spring 0.20 mg/L and lower at the Laam site during autumn (Table 65). The higher values of phosphate could be due to surface runoff from agricultural fields as has also been observed by (Zubair and Ahrar, 2013).

Table 66 Mean value of metal concentrations (ppb) at the four stations of of Dal Lake.

S.No.	Name of the Metal	Hazratbal	Habbak	Laam	Brarinambal
1	Molybdenum	2.538± 0.002	1.703± 0.003	3.627± 0.004	4.787 ± 0.002
2	Chromium	ND	ND	ND	ND
3	Arsenic	2.711 ± 0.029	3.098 ± 0.0008	0.006 ± 0.0007	2.324 ± 004
4	Cadmium	0.099 ± 0.001	0.494 ± 0.244	0.494 ± 0.243	0.989 ± 0.002
5	Lead	6.828± 0.003	2.492 ± 0.002	5.364 ± 0.004	6.292 ± 0.007

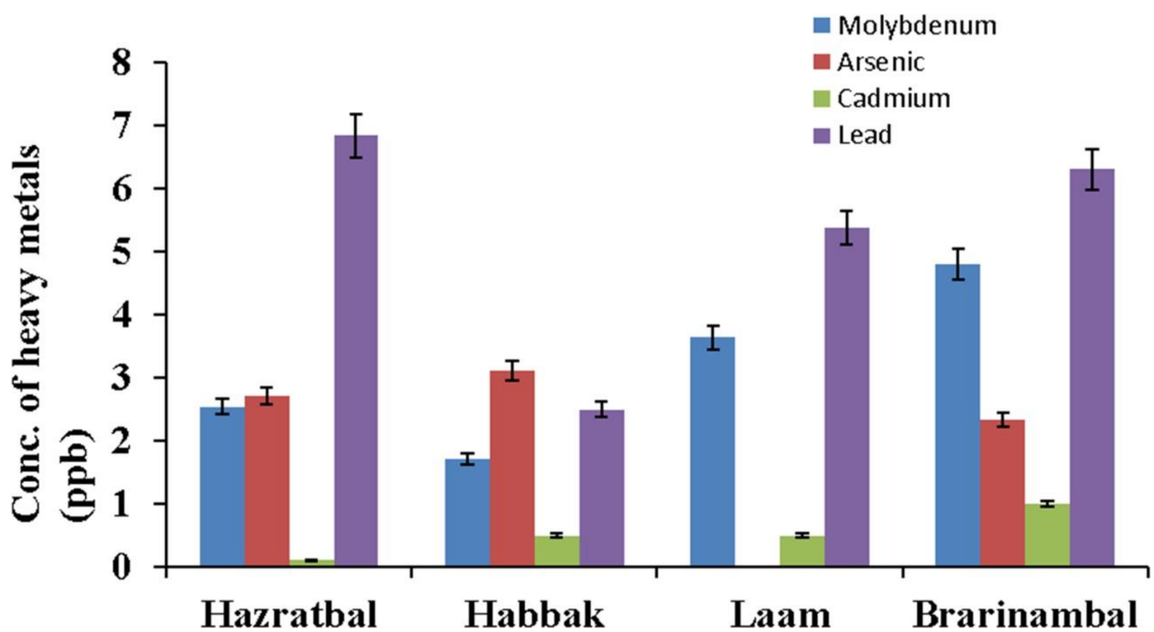


Figure 32. Heavy metal concentration at the different study sites with in Dal Lake.

HMs have density five times greater than water, generally present in trace amounts however some of them are toxic even in very minute concentrations. Some of these HMs are needed to perform the physiological functions of plants and animals but slightly higher doses are responsible for hampering the biochemical processes.

The values of HMs showed variation between the four sites of the Dal Lake (Table 66). The values of molybdenum in ppb concentrations between the sites was found to be 2.538 ±0.002, 1.703± 0.003,3.627±0.004 and4.787± 0.002 ppb. at the four sites of the Lake respectively, the highest values of molybdenum were reported at the Brarinambal (Site iv) and lowest values at the Habbak site of the water body (Bahnasawy et al., 2011 and Khan et al., 2012). The chromium being highly toxic was not detected in any of the four sites of the water body during the present study which is a potential cause of many cancers. Arsenic which is mainly found in the waste waters and due to the pesticide pollution, and are mainly incorporated into the Dal Lake because of UN recommended doses of pesticides used in the floating gardens. The highest and lowest values of Arsenic were observed at the Habbak site 3.098 ± 0.0008 and Laam site 0.006 ± 0.0007 ppb. respectively. Levels of Arsenic decreases during the rainy season because the wastes are washed away during rainfall. Arsenic bio accumulates in the body and has been found to cause arsenosis (Wahlberg et al., 2002; Bhat, 2018).

The values of cadmium ranged from 0.989± 0.002 ppb at Brarinambal to 0.099± 0.001 ppb at the Hazratbal site of the Dal Lake. Increase in Cadmium concentration was possibly due to increased number of suspended solids (Tarras et al., 1986, Moturi et al., 2005). The concentrations of mean values of lead showed highest values of 6.828± 0.003 ppb at Hazratbal site of the Lake, and the lowest concentration at the Habbak site 2.492± 0.002 ppb of the Dal Lake due to increased anthropogenic activity and dumping of municipal and sewage wastes. Similar type of results was observed by (Muller et al., 2008; Ntakirutimana et al., 2013). Following their entry into the lake waters HMs are scavenged by hydroxides of iron and manganese, thereby determining the heavy metal behavior along with particulate matter (Stumm and Lee, 1960). Variations in the values of HMs between the sites can be due to leaching of agricultural and surface runoff thereby accelerating the average values at the different sites of the Lake (Morgan and Stumn, 1991).

6.6. Economic evaluation of Dal Lake.

Putting a price on the benefits and other services acquired from a system is what economic valuation of an environmental resource actually means (Freeman, 1993). As a result, economic valuation aids in determining or approximating the optimal. Although an economic valuation technique may not reflect all values, such as the intrinsic values of the system (Verma et al., 2001), it is nevertheless useful because it allows one to depict practically all of the products and services provided by an environmental resource (Brendan et al., 2011).

Dal Lake, the current study site, provides a varied range of services, including drinking water, recreation (tourist), microclimate stability, ground water recharge, and so on (Siew et al., 2015). However, anthropogenic influences such as sewage, siltation, surface runn off from agricultural fields in the catchment area, detergents, soaps, feces, decaying organic matter, tourism, water abstraction, pollution arising from socio-religious activities, and others are reducing this environmental resource to an undervalued and under-recognized aquatic ecosystem (LAWDA,2000; Zhu Lin et al.,2011). As a result, the current study was started in order to quantify the economic values of some of the services provided by the Dal Lake.

Economic valuation of Dal Lake includes all the benefits that are currently being retrieved and have been calculated as part of this research. Instead of option and existence values, numerous actual/current values have been represented using direct and indirect valuation approaches in this attempt. Because stakeholders derive numerous benefits from the lake, actual values have not been added together to calculate total economic worth (TEW).

6.6.1 “Valuing direct uses”

Using this strategy, it was attempted to provide a value to all the direct economic benefits, whether through direct costing, market price, or current production resulting from the wetland. The following are the many use values and valuation approaches used.

6.6.2. “Evaluation of drinking water supply (Full Supply Cost)” The cost of supply covers the costs of operation and maintenance, capital charges, and the costs of providing water to a customer. Despite the fact that a variety of agencies such as the Rural Development Department, Wildlife Department, Jal shakti department and others are extracting water from the lake, no other agency but the Public Health and Engineering Department (PHE) keeps track of the amount of water they extract. Only PHE department, extracts about 5.6 million gallons of water per day and supply it to about one lakh eighty thousand population having about thirty thousand registered connections.

Table 67 Annual turn over of PHE water supply scheme for the year (2020 -2021).

S. No.	Revenue/Expenses	2020		2021	
		Earning	Expenses	Earning	Expenses
1	Total No. of Registered Water Supply Connections	**28000 (Assessed on** March 2021**)**		**29979** **(**Assessed on 12-11-2021**)**	
2	Total number of Souls benefitted	**175000**		**185000**	
3	Total revenue Generated (Rs)	7,84,00000	-	8,39,41200	
4	Electricity Bill (Rs)		1,50,00000		1,50,00000
5	Maintenance Costs (Rs)				
6	Salaries				
7	Profit	6,30,00000		68941200	

Source: Assistant Engineer PHE Division Srinagar

The above table (Table 67) indicates an increase in revenue from 6,30,00000 in 2020 to 6,89,41200 in 2021 due to increase in number of connections, the revenue collected however is low because of the inability of the people to pay the water tariff regularly. The department intends to go for the installation of pre paid meters to collect the revenue with out any fail.

As a result, instead of the actual money recovered the department projects to collect some 45 crores annually, this deficit is expected to be overcome by the installation of pre paid meters which the department is mulling to install soon and the process has already started. Similar results are also reported in India by (Ramachandra et al., 2011) and in the great Ethopian lakes by (Legesse et al., 2004). Dal Lake receives a large number of tourists each year, most of them leave at the end of the day and just a few stays overnight.

Table 68 Tourist arrival to Kashmir valley during the year 2019.

Month	**2019**		
	Domestic	**Foreign**	**Total**
January	22615	2480	**25095**
February	11395	4508	**15903**
March	14805	6432	**21237**
April	53648	8167	**61815**
May	79633	1506	**81139**
June	162090	2669	**164759**
July	149095	3430	**152525**
August	9285	845	**10130**
September	3958	604	**4562**
October	8503	824	**9327**
November	10946	1140	**12086**
December	5780	1174	**6954**
Total	**531753**	**33779**	**565532**

Table 69 Tourist arrival to Kashmir valley for the year 2020 and 2021.

Month	2020			2021		
	Domestic	**Foreign**	**Total**	**Domestic**	**Foreign**	**Total**
January	3792	1071	**4863**	19042	60	**19102**
February	6453	1729	**8182**	26064	154	**26218**
March	3807	836	**4643**	48026	136	**48162**
April	-	-	**0**	32520	74	**32594**
May	-	-	**0**	1109	19	**1128**
june	-	-	**0**	15176	78	**15254**
July	175	11	**186**	39489	115	**39604**
August	251	33	**284**	38566	92	**38658**
September	814	34	**848**	27756	85	**27841**
October	2659	38	**2697**			
November	6271	56	**6327**			
December	13148	89	**13237**			
Total	37370	3897	**41267**	247748	826	**248561**

Source: JK Tourism Dept.

Table (68, 69) indicate the number of tourists who visited the valley. During (2021) 900 shikaras and 30 motor boats were found to be available in the Dal Lake to carry the tourists to the different places with in the water body and generate revenue for their sustenance and there by contribute to the economy of the state. The following are the typical boating earnings:

Number of Shikaras = 900

Fair per ride = Rs 500

Fair every two rides = Rs 1000

Shikaras used every day = 400

Revenue generated everyday by 400 Shikaras = 400×1000= Rs 400000

Revenue generated per month for 20 days only = 20× 400000 = Rs 8000000

Revenue generated in 2021= 8000000×4 = Rs 32000000 (June-Sept)

Maintenance cost 2021 @1000/Shikara = Rs 900000

Profit = 32000000-900000 = Rs **31100000**

Motor Boats:

Total number of Motor Boats = 30

9- Seater capacity = 18

4- Seater capacity = 12

Rate 9- Seater Motor Boat = Rs 400/ head/ride

Rate 4-Seater motor boat = Rs 500/head/ride

Number of trips made by motor boats per day= 5 trips

Fare generated every day by 9- Seater = 400× 9×5 = Rs 18000

Fare generated every day by 4- Seater = 500×4×5 = Rs 10000

Fare generated every day by 18 (9- Seater) = 18×18000 = Rs 324000

Fare generated every day by 12 (4- Seater) =10000×12 = Rs 120000

Number of working days every month for motor boats = 20 (Minimum)

Fare generated every month by 9- Seater = 324000×20 = Rs 6480000

Fare generated every month by 4- Seater = 120000×20 = Rs 2400000

Total fare generated by 9- Seater and 4- Seater capacity boats = 6480000 + 2400000= Rs **8880000**

Fare generated by motor boats for 4 months in 2021(June- Sept.) = 8880000×4= Rs **35520000**

Fuel consumption by a motor boat every day= 800

Fuel consumption by 30 motor boats everyday= 800×30= 24000

Fuel consumption every month (Minimum 20 days) = 24000×20= Rs 480000

Maintenance = Rs 30000 per boat per year

For 30 boats= 30000×30 = Rs 900000

Fuel consumption for 4 months = 480000×4 = Rs **1920000**

Fare generated by motor boats = Fare- Fuel prize- Maintenance

=35520000- (1920000+ 900000)

=35520000- (2820000)

= Rs **32700000**

Hotels and House boats:

Hotels:

Total number of hotels=430

Average number of Rooms= 10

Total rooms = 4300

No. of rooms occupied per day= 3000

Rent per room per day= 750

Rent for 3000 rooms per day= 3000×750 = Rs 2250000/day

Rent for 3000 rooms per month= 2250000× 30 = Rs 67500000

Rent generated for 2021 (Jan- March, June- Sept.) = 67500000×7= Rs **472500000**

Maintenance (Salaries, water bill, Electricity charges, Misc charges) = Rs 173576000

Profit = 472500000- 173576000 = Rs **298924000**

House boats:

Total number of House boats=900

Average number of Rooms= 3

Total rooms = 2700

No. of rooms occupied per day= 300

Rent per room per day= 1200

Rent for 300 rooms per day= 300×1200= Rs 360000 per day

Rent for 300 rooms per month = 360000×30= Rs 10800000

Rent generated for 2021 (Jan- March, June- Sept.) = 10800000×7= Rs **75600000**

Maintenance (Water Bill, Electricity charges) = Rs 9280000

Profit = 75600000- 9280000 = Rs **66320000**

Table 70 Annual turn over of registered hotels around the Dal Lake for the year (2020-2021).

Years	Number of Hotels	2021
Revenue (Rs)	430	47,25,00000
Electricity Bill (Rs)	Category A= 87 Category B= 115.	10,320,000
Water Bill (Rs)	Category C/D=228	51,6000
Salaries (Rs)		16,25,40,000
Maintenance Cost (Rs)		20,0000
Profit (Rs)		**29,89,24000**

Source: JK Tourism, Srinagar

Tabel 71 Annual turn over of registered house boats in the Dal Lake for the year (2020-2021).

Years	Number of Houseboats	2020-2021
Revenue (Rs)	Total House boats in Dal Lake =900	75,60,0000
Electricity Bill (Rs)	(Registered= 700	81,00000
Water Bill (Rs)	UnRegistered = 200)	10,80000
Salaries (Rs)		Nil
Maintenance Cost (Rs)		100000
Profit (Rs)		**66,32,0000**

Table 72 Number of shikaras and motor boats in Dal Lake.

Year	Number of Shikaras	Revenue Generated	Maintenance	Profit	Number of Motor boats	Maintenance	Revenue Generated	Profit
2021	900	32,000000	900000	**31,100000**	30	**2820000**	**35520000**	**32700000**

The above tables (70-72) indicate that there is a considerable amount of revenue generated by hotels and house boats during the study period, however the amounts generated could have been much higher if the COVID restrictions would not have been implemented through out the country which negatively affected the revenue generation of the hotel and house boat industry. The shikara and boat riders also earn significantly good amount of money during the peak tourist seasons however again due to lock down this sector also faced a problem to earn their livelihood. The information related to table 72 has been gathered from Mr. Bashir Shikari (president of fruitseller's association of Dal Lake year 2020-21.

a) **Tea Stall| Dhabas:** There are about 80 tea stalls in the vicinity of Dal Lake.

Average earning of Stall per day **= 500**

Average income per day for 80 stalls=80×500= 40000

Average income per month (Min. 25 working days) = 40000×25=1000000

Average income for 2021 (7 months, Jan- March, June to Sept 1000000×7=**70,00000**

b) **Handicrafts:**

Total number of handicraft shops=100

Average earning per shop per day **=** 2000

Average income per day for 100 shops = 2000×100=200000

Av. Income for one month (25 working days) = 200000×25=5000000

Av. Income for 2021 (7 months) =5000000×7= **35,000000**

c) Public Toilets:

Total number of public toilets= 300

Average number of vistors using public toilets= 30

Av. Cost of using toilet = 10

Av. Cost of using 1 toilet everyday by 30 users= 30×10=300

Av. Cost of using 1 toilet every month = 300×30=9000

Av. Cost of using 300 toilets every month= 9000×300=2700000

Av. Cost of using 300 toilets for 2021 (7 months) =2700000×7=**18,90,0000**

d) Public Parks:

Total number of Parks =8

Ticket entry for three parks only (Nishat, Shalimar and Botanical Garden)

Av. Number of visitors visiting per park=2500

Av. Cost of ticket entry for 2500 tourists visiting 1 park @ 24|= per person =2500×24=60000

Av. Cost of ticket entry for 2500 tourists visiting 3 parks per month= 60000×3=180000

Av. Cost of ticket entry for 2021 (4 months June- Sept) =180000×4=**72,0000**

e) Shopping Complexes:

No. of shopping complexes=80

Av earning per day per shopping complex=3000

Av. Income per day by 80 shopping complexes= 3000×80=240000

Av. Income per month (25 working days) = 240000×25=60,00000

Av. Income for 2021 (7 months) = 6000000×7=**42,000000**

f) Golegappa Peddlers:

Total number of golegappa peddlers=50

Av. earning per day =500

No. of working days per month =20

Av. Income per month for 1 peddler=500×20= 10000

Av. Income per month for 50 peddlers= 10000×50=500000

Av. Income generated by 50 peddlers in 2021 (4 months June- Sept.) =500000×4=**20,00000**

g) Ice- cream | Soft drink Parlors:

Total number of Parlors= 500

Av earning per day per parlor= 600

Av. Working days per month=20

Av. earnings per month per shop=600 ×20=12000

Av. income per month for 500 shops=12000×500= 6000000

Av. income generated by 500 shops in 2021 (4 months) = **24,000000**

Vegetable| Floating market in DalLake: (Wani et al., 2013)

1) Nadroo (season Sept to March)

Nadroo production per day=750 chakh

Normal Nadroo 1 chakh =4 gaji

1 gaji=1.5kg

Special (Toiba gaji) = 3kg

Out of 750 (50 are Toiba gaji and 700 are normal gaji)

Rate of Normal Nadroo 1 gaji=200|=

Rate of Toiba gaji=500

Cost of 700 normal chakh per day =4×700×200=560000

Cost of 50 Toiba chakh=50×4×500= 100000

Cost of Normal nadroo per month=560000×30=16800000

Cost of Toiba nadroo per month=100000×30= 3000000

Total cost of Toiba plus normal nadroo per month =16800000+3000000=19800000

Total cost for Nadroo for 7 months= 19800000×7=**13,86,00000**

2) Trapa (Season March- Oct.)

Trapa production per day= 35 kg

Rate of Trapa=60|kg

Cost of Trapa sold per day= 35×60=2100

Cost of Trapa sold per month= 2100×30= 63000

Cost of Trapa sold per 8 months= 63000×8= **50,4000**

2) HAAKH (Entire year)

Haakh production per day = 30 Quintal

Rate of Haakh per Quintal in the Floating Garden=1600|=

Cost of Haakh sold per day=1600×30=48000

Cost of Haakh sold per month=48000×30= 1440000

Cost of Haakh sold per year = 1440000× 12= **17,28,0000**

3) **Muji- Gogji (Radish and Turnip) (Sept-March)**

Production of Radish and Turnip= 15 Quintal each per month

Cost of 1Quintal = 1300

Cost of 30 Quintal = 1300× 30= 39000

Cost of Radish and Turnip for 7 Months= 39000×7= **27,3000**

4) **Carrot (Sept- March)**

Production per month =20 Quintal

Cost of Carrot = 2000| Quintal

Cost of carrot produced per month= 2000×20 = 40000

Cost of carrot produced in seven months= 40000×7=**28,0000**

5) **Bottle Gourd and Cucumber (May-Oct.)**

Production of Gourd and Cucumber = 5 Quintal |day

Cost of 1 Quintal of Gourd cucumber= 2000| Quintal

Cost of 5 quintals = 2000× 5= 10000| day

Cost of Gourd cucumber sold per month= 10000×30= 300000

Cost of Gourd Cucumber sold for 6 months = 300000×6= **1800000**

6) **Tomato (May –Oct.)**

Production of Tomato = 30 Quintal |month

Cost of 1 Quintal = 1500

Cost of Tomatos produced per month= 15×30= 45000

Cost of Tomatos produced in 6 months=45000×6= **270000**

7) **Brinjal (May-Oct.)**

Production per month= 20 Quintals

Rate per Quintal= 3000

Rate of Brinjal Produced per month= 20×3000= 60000

Rate for 6 months = 60000×6= **360000**

8) **Spinach (yearly)**

Production of Spinach per month = 30 Quintal

Cost per Quintal= 5000

Rate of Spinach produced per month=5000×30= 150000

Rate of Spinach per year =150000×12= **1800000**

9) **Capsicum (June- Augst**)

Production of Capsicum = 20 Quintal |month

Cost per Quintal = 5000

Cost of production per month= 5000×20= 100000

Cost of production for 3 months= 100000×3= **300000**

10) **Bhindi (May- Oct.)**

Production of Bhindi per month= 9 Quintal

Cost per Quintal = 3000

Cost of Bhindi sold per month= 9×3000= 27000

Cost of Bhindi for 6 months= 27000×6= **162000**

11) **Dhaniya (May- Oct.)**

Production of Dhaniya per month= 6 Quintal

Cost per Quintal = 2500

Cost of Dhaniya produced per month= 2500×6= 15000

Cost of Dhaniya produced for 6 months= 15000×6= **90000**

12) Spring Onion (March- April)

Production of Spring Onion= 12 Quintal |month

Cost of Spring Onion= 5000\Quintal

Cost of spring onion produced per month= 5000×12= 60000

Cost of spring onion produced for 2 months= 60000×2= **120000**

Income Generated by Selling Vegetables Annually = 16,18,66,000

6.6.3. Cost of illness approach and defensive costs

Every year, a good number of tourists visit Dal Lake because of its mesmerizing beauty. Though tourism has created and maintained jobs, the influence on the water quality of the lake has been noted to be vast and variable. Furthermore, anthropogenic factors such as sewage, siltation, fecal matter, detergents, soaps, washing and bathing, fertilizers from the catchment region, encroachment, ill-planned development, and so on have spelled doom to the water quality of this valuable freshwater reservoir. The quality of water has degraded to the point where water borne infections are frequent among those who consume lake water. Furthermore, many people do not use healthy water purifying measures other than the chlorine tablets obtained from Primary Health Centers due to misinformation. In other words, it is reasonable to conclude that individuals are unconcerned about the repercussions of their brutal approach to the lake. And, if a person becomes ill as a result of a water-borne disease, the expenses to cure from them borne by him or her turn out to be a significant expense. The number of working days lost due to illness ads to the cost of illness (Zuber, 2007).

Year after year, the frequency of water-borne infections has been observed to rise (Table 73). Patients who sought medical treatment from private practitioners rather than government hospitals are not included in the data in (table 73), GIT (diarrhea/dysentery), worms, viral fever and ascariasis, appear to be the most common water-borne diseases reported by the Department of Health from the study area. On the basis of the survey, it can be assumed that the tentative/ estimated expenditure on each of these diseases turns out to be something around:

1. For treatment of Gastro-enteritis minimum 550 to 1400 rupees are incurred (Average 1200).
2. For Diarrrhoea 300 to 700 rupees are incurred on the treatment (Average 600).
3. For worms 200 to 400 rupees are incurred (Average 300).
4. For viral fever treatment 800 to 1500 rupees are incurred on the treatment (Average 1400).
5. For the treatment of ascariasis 300 to 600 rupees are incurred (Average 450).

Perusal of the (Table 71) indicate that people spent huge amount of money to recover from the diseases caused due to unhygienic drinking water. Out of the water borne diseases highest amount of money was spent on the treatment of diarrhea which amounted to rupees 1599000|= during the year 2021 and lowest in ascariasis which was 488250.

Table 73 Incidence of water borne diseases in the catchment of Dal Lake and the cost incurred (2020-2021) (Health Department, Srinagar).

Year	2020			2021		
S. No.	**Water Borne Disease**	**No. of Cases**	**Cost incurred (in Rs.)**	**Water Borne Disease**	**No. of Cases**	**Cost incurred (in Rs.)**
1.	**GIT**	840	10,08000	**GIT**	785	942000
2.	**Diarrhoea**	2645	15,87000	**Diarrhoea**	2665	1599000
3.	**Worms**	2700	81,0000	**Worms**	2100	630000
4.	**Ascariasis**	1200	540000	**Ascariasis**	1085	488250
	Total	10945	**39,45000**	**Total**	18635	**36,59,250**

Furthermore, people employ defensive strategies for acquiring safe drinking water in order to avoid the disease that also contributes to the economy of the lake and state. Mansar lake of Jammu was also evaluated on the same lines by (Zuber, 2007).

6.6.4. Travel cost method

The Travel cost method, which is comparable to the direct observed techniques discussed above, but these values must be derived from a relationship between observed activity and the environmental service (Freeman, 1993). The costs of reaching to a location are used for visitation market prices in the travel cost approach. Faber and Costanza, (1987) used this method to study wetlands recreation in Terrebonne Parish, Louisiana. Individual consumer surplus was projected to be $6.00 per year, which compares favorably to the contingent value estimated consumer surplus value of $4.86.

The travel cost approach, for which a questionnaire was designed, was used to analyze the recreational benefits and the cost paid on travel and related activities. The questionnaire included two sections, one dealing with the respondents' social backgrounds and the other with the costs associated with various travel-related activities.

6.6.5. Sample characteristics

A sample of 296 respondents was selected for the current study. These respondents were mainly from North, South and Eastern States of India.

Characteristics of respondents under TCM survey

Of all the respondents interviewed during the present survey, most of the people were self employed (60.6%) followed by private sector (20.3%) and Govt. sector (12.3%) (Table 74). And majority of the people were graduates (35.2%) followed by inter school (33.0%) (Table 75). The main income group falled in the range of 3 to 5 lakh (86.7%) followed by less than 25000 (13.3%) (Table 76).

Table 74 Occupation of the respondents.

S. No.	Occupation	Percentage
1.	Private Sector Employee	20.3
2.	Government Employee	12.3
3.	Self Employed	60.6
4.	Others (Please Specify)	6.8

Table 75 Formal education level of the head of the household or the respondent.

S. No.	Education Level	%age
1	Below Class X	Nil
2	Upto Class XII	33.0
3	Undergraduate / Graduate	35.2
4	Post Graduate	10.0
5	Professional Qualification (B.E./ B. Tech./ M.B.A./ M.B.B.S.)	8.5
6	Others	13.3

Table 76 Households total gross income.

Income Category	Percentage	Income
< Rs. 25,000	13.3	232750
Rs. 25,000 – Rs 50,000	0.0	Nil
Rs. 50,000 – Rs 1 Lakh	0.0	Nil
Rs. 1 Lakh – Rs 2 Lakh	0.0	Nil
Rs. 2 Lakh – Rs. 3 Lakh	0.0	Nil
Rs. 3 Lakh – Rs. 5 Lakh	86.7	34680000
Total	100	**34912750**

Respondent's family structure was observed and it was found that (50.7%) were below the age of 18 years and (28.4%) were above the age of 18 years (Tables 77, 78).

Table 77 Number of house hold members below the age of 18.

S. No.	No. of Family Members	Percentage
1	1	41.3
2	2-3	50.7
3	4-5	8.0
4	5-6	0.0

5	**6-7**	**0.0**
6	**Nil**	**0.0**

Table 78 Number of house hold members above the age of 18.

S. No.	No. of Family Members	Percentage
1	**2 – 3**	27.0
2	**3 – 4**	28.4
3	**4 – 5**	31.3
4	**5 – 7**	0.0
5	**7 - 10**	13.3

Majority of the respondents (86.8%) visited once in 1-2 years and 13.2% respondents visited once in a week who were local people (Table 79).

Table 79 Frequency of visit to Dal Lake.

S. No.	Frequency of visit	Percentage
1	**Once in a week**	13.2
2	**Once in a fortnight**	0.0
3	**Once in a month**	0.0
4	**Once in 2 – 6 months**	0.0
5	**Once in 7 – 12 months**	0.0
6	**Once in 1 – 2 years**	86.8

Since the Dal Lake has many religious places located on its banks which are very sacred for Hindu community such as Shankaracharya Mandir, Hazratbal shrine (Muslims) and Chattipadshahi Gurduwara (Sikhs). Most of the people (86.8%) visited for recreational purposes and (13.2%) people visited for religious purposes (Table 80). However local people visit for recreational purposes mainly in the evening hours. But Isangkura (2003) found that many local residents with low-income living near Dointhanon visit the park regularly for recreation purposes.

Table 80 Purpose of visit to Dal Lake.

S. No.	Purpose to visit Dal Lake	Percentage
1	**Recreational**	86.8
2	**Religious**	13.2

Most of the people who visited Dal Lake during the present survey travelled through private car/tempo (24.5%) followed by local bus (23.2%), contract car (19.3%) and Air (17.0%) (Table 81).

Table 81 Mode of travel opted.

S. No.	Mode of Travel to Dal Lake	Percentage
1	**Private Car/Tempo**	24.5
2	**Contract Car**	19.3
3	**Contract Bus**	16.0
4	**Local Bus**	23.2
5	**Train / Air**	17.0

(41.2%) respondents said that it took them 0-1 days to prepare for the trip and (33.3%) respondents said it took them 1-2 days to prepare for the trip, while (25.5%) said that it took them 2-3 days to prepare (Table 82). The wages forgone for the trip to get materialized was rupees 28329.50|= (Table 83).

Table 82 Number of days required to prepare for the trip

S. No.	No. of Days	%age
1	**0 – 1 days**	41.2
2	**1 – 2 days**	33.3
3	**2 – 3 days**	25.5
4	**3 – 4 days**	0.0
5	**4 – 5 days**	0.0

Table 83 Wages incurred for the preparation of this trip

S. No.	Amount	Percentage	Wages Forgone
1	< Rs 100	39.3	2947.5
2	Rs. 100 – Rs 250	4.0	700
3	Rs. 250 – Rs 500	41.5	15562
4	Rs. 500 – Rs 750	0.0	NIL
5	Rs. 750 – Rs 1000	0.0	NIL
6	> Rs 1000	15.2	9120
Total			**28329.50**

The average amount spent on travelling was in the range of 500-1000 followed by 1000-2000 and the total amount spent was about 70035 rupees (Table 84).

Table 84 Expenditure on fuel and travelling for visiting Dal Lake

S. No.	Amount	Percentage	Expenditure Incurred
1	Rs 10 – Rs 50	0.0	NIL
2	Rs 50 – Rs 100	8.0	600
3	Rs 100 – Rs 250	31.2	5460
4	Rs 250 – Rs 500	0.0	NIL
5	Rs 500 – Rs 1000	36.3	27225
6	Rs 1000 – Rs 2000	24.5	36750
Total		100.0	**70035**

Similarly maximum respondents spent money in the range of 1000-2000 followed by 500-750 and the money spent on boarding and lodging was 110500 rupees (Table 85).

Table 85 Expenditure on boarding and lodging

S.No.	Amount	Percentage	Expenditure Incurred
1	Rs 50 – Rs100	0.0	NIL
2	Rs 200 – Rs 500	8.0	2800
3	Rs 500 – Rs 750	33.2	20750
4	Rs 750 – Rs 1000	2.0	1750
5	Rs 1000 – Rs 2000	56.8	85200
6	> Rs 2000	0.0	NIL

Total	100.0	**110500**

The maximum money spent on snacks was in the range of 1000-1500 followed by 500- 750 and the net amount totaled to 92812.50 rupees (Table 86).

Table 86 Expenditure on food and snacks.

S.No.	Amount	Percentage	Expenditure Incurred
1	**Rs 100 – Rs 250**	0.0	NIL
2	**Rs 250 – Rs 500**	8.0	3000
3	**Rs 500 – Rs 750**	35.2	22000
4	**Rs 750 – Rs 1000**	8.5	7437.50
5	**Rs 1000 – Rs 1500**	48.3	60375
6	**> Rs 1500**	NIL	NIL
Total		100.0	**92812.50**

Similarly, a maximum of Rs 500 to 1000 (56.8%) was spent on beverages followed by 100-200 and the total money spent was about 53080/= (Table 87).

Table 87 Expenditure on beverages.

S. No.	Amount	Percentage	Expenditure Incurred
1	**Rs 50**	0.0	NIL
2	**Rs 50 – Rs 100**	0.0	NIL
3	**Rs 100 – Rs 200**	23.2	3480
4	**Rs 200 – Rs 500**	20.0	7000
5	**Rs 500 – Rs 1000**	56.8	42600
6	**> Rs 1000**	0.0	NIL
Total		100	**53080**

It was observed that (23.8%) people spent 250-500 on boating and the amount spent on this was rupees 20600 (Table 88).

Table 88 Expenditure on boating and rafting.

S. No.	Amount	Percentage	Expenditure Incurred
1	**Rs 10 – Rs 50**	0.0	NIL
2	**Rs 50 – Rs 100**	0.0	NIL
3	**Rs 100 – Rs 150**	33.2	4150
4	**Rs 150 – Rs 200**	43.0	7525
5	**Rs 250 – Rs 500**	23.8	8925
6	**Rs 500 – Rs 750**	0.0	NIL
Total		100.0	**20600**

Perusal of the data indicates that the (Table 89 and 90) respondents did not spend too much on the trip yet a significant amount of money was incurred on the trip (Money expected to be spent and money actually spent).

Table 89 Expenditure intended/expected on trip.

S. No.	Amount	Percentage	Expected Amount
1	**< Rs 100**	0.0	NIL
2	**Rs 100 – Rs 500**	0.0	NIL
3	**Rs 500 – Rs 1000**	10.0	7500
4	**Rs 1000 – Rs 2000**	25.2	37800
5	**Rs 2000 – Rs 3500**	25.0	68750
6	**> Rs 4000**	39.8	99500
Total		100.0	**213550**

Table 90 Expenditure actually done on this trip.

S. No.	Amount	Percentage	Actual Amount Spent
1	**< Rs 100**	0.0	NIL
2	**Rs 100 – Rs 500**	15.3	4590
3	**Rs 500 – Rs 1000**	8.0	6000
4	**Rs 1000 – Rs 2000**	25.2	37800
5	**Rs 2000 – Rs 3500**	10.0	27500
6	**> Rs 4000**	41.5	103750
Total		100.0	**179640**

Scenic beauty and recreational activity were found to be the main driving force of the tourists (Table 91) however the difficult terrain, security concerns and the pandemic conditions prevalent during the study period hampered the visitors to the lake (Table 92).

Table 91 Factors which influence you to visit the Dal Lake.

S.No.	Factors	Percentage
1	Religious / Sacred Place	0.0
2	Scenic Beauty	90.0
3	Recreation and Relaxation Purposes	8.0
4	Picnic Purposes	2.0

Table 92 Factors which hamper your visit to the Dal Lake.

S. No.	Factors	Percentage
1	Poor Roads	50.2
2	Security Concerns	49.8
3	Lack of Basic Facilities	0.0
4	Landslides	0.0

6.6.6. Contingent valuation method (CVM)

This method is one of the most dependable valuation methods for estimating the value of environmental goods (Birol et al., 2005). CVM involves evaluation of the value of an environmental product or service by directly asking individuals their willingness to pay (WTP) or accept (WTA) for the environmental resource usually using a survey questionnaire (Cameron, 1988).

CVM has the primary advantage of being able to elicit both use and non-use values, this strategy involves asking people to express their valued decisions regarding potential environmental changes in a variety of methods (Mathews et al., 2001):

1. Environmental improvement: The environmental improvement is calculated as follows:

a) The maximum willingness of a person to pay (WTP) for environmental improvement or protection

b) The minimum willingness of a person to accept (WTA) in exchange for sacrificing environmental improvement

2. Environmental damage: The value of the environmental damage can be measured either by:

a) the maximum willingness of an individual to pay (WTP) compensation to avoid the environmental damage.

b) the minimum willingness of an individual to accept (WTA) compensation to consent the environmental damage.

The questionnaire used in the current study was divided into two sections, one dealing with the attitude and the other with the scenario building.

A. Attitudinal questions This section included some questions about the interviewee's perspective and opinions on the country's numerous difficulties. These questions were followed by a series of questions aimed at gathering information on the sources of drinking water in their homes, as well as if they were aware of the threats to the lake's very existence as local people were found to be mainly responsible for imblancing the ecological balance of the Lake by discharging pollutants (Uzun et al., 2008; Kumari, 2007).

B. Scenario building In this section, people were informed about the proposed Dal Lake Management Society and the benefits they would derive as a result of the society's actions. They were also asked about the improved aesthetic and recreational benefits that the society would provide to the citizens. Then two sorts of payment vehicles were utilized: a voluntary payment to the management society in exchange for discounted advantages, and a compulsory tax that would go to the management society but would not provide people with any privilege benefits. In addition, an open-ended bidding competition was employed to moniter the public willingness to pay for the particular services.

6.6.7. Econometric models for economic evaluation

For each of the two payment methods utilized in the current survey, at least two regression models were estimated. The Willingness to Pay Voluntarily, VOLDON, is the dependent variable in the first equation. The dependent variable in the second equation is the willingness to pay for the same benefits in the form of a tax, VPOCTAX. Both of these were then regressed against a vector of socio-economic characteristics like income and education level, as well as a set of dummy variables.

General form of the equation

1. VOLDON = *f* (CONSTANT, HOYDVL, CATINCOM, SWYHBSDL, NFMA, FEDLHH, NFMB, OCC, FEDLHH, HODYVL, PED)

Where VOLDON = the voluntary donations/voluntary WTP

CATINCOM	= the category of income of the entire family
FEDLHED	= the formal educational status of the person questioned
NFMB	= the number of minor family members below eighteen years.
NFMA	= the number of family members above eighteen years.
SWYHBSDL	= the length of residence along Dal Lake
OCC	= the occupation of the respondent
HODYVL	= how often do you visit Dal Lake
PED	= Pollution and Environmental Degradation

2. VPOCTAX= *f* (CONSTANT, CATINCOM, FEDLHED, NFMB, NFMA, SWYHBSDL, OCC, HOUVL, PED)

The logarithm linear form of the equation

LOGVOLDON= $\alpha + \alpha_1$ LOGCATINCOM + β_1 FEDLHED + β_2 NFMB + β_3 NFMA + β_4 SWYHBSDL + β_5 OCC + β_6 HOUVL + β_7 PED

The estimated results of these equations are as follows:

Voluntary donations

Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.145[a]	.021	.001	1.13566	.021	1.050	8	391	.398

a. Predictors: (Constant), PED, CATINCOM, SWYHBSDL, HODYVL, NFMA, NFMB, FEDLHH, OCC
b. Dependent Variable: VOLDON

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	**Regression**	10.832	8	1.354	1.050	.398[b]
	Residual	504.278	391	1.290		
	Total	515.110	399			

a. Dependent Variable: VOLDON
b. Predictors: (Constant), PED, CATINCOM, SWYHBSDL, HODYVL, NFMA, NFMB, FEDLHH, OCC

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	**(Constant)**	3.356	.998		3.361	.001			
	HODYVL	-.302	.215	-.132	-1.401	.162	.004	-.071	-.070
	CATINCOM	-.012	.053	-.012	-.227	.820	-.019	-.011	-.011
	SWYHBSDL	-.029	.114	-.018	-.258	.796	.027	-.013	-.013
	NFMB	.107	.106	.067	1.008	.314	.025	.051	.050
	NFMA	.069	.084	.055	.814	.416	-.028	.041	.041
	FEDLHH	-.109	.060	-.138	-1.813	.071	-.025	-.091	-.091
	OCC	.337	.180	.263	1.875	.061	.075	.094	.094
	PED	.019	.090	.022	.207	.836	-.059	.010	.010

a. Dependent Variable: VOLDON

Coefficient Correlations[a]

Model			PED	CATINCOM	SWYHBSDL	HODYVL	NFMA	NFMB	FEDLHH	OCC
1	Correlations	PED	1.000	-.002	-.553	-.655	-.137	-.002	.035	.761
		CATINCOM	-.002	1.000	.035	.002	.112	-.077	-.180	.031
		SWYHBSDL	-.553	.035	1.000	.530	.194	-.180	-.169	-.566
		HODYVL	-.655	.002	.530	1.000	.105	-.380	.147	-.762
		NFMA	-.137	.112	.194	.105	1.000	-.232	-.481	.211
		NFMB	-.002	-.077	-.180	-.380	-.232	1.000	.239	.126
		FEDLHH	.035	-.180	-.169	.147	-.481	.239	1.000	-.347
		OCC	.761	.031	-.566	-.762	.211	.126	-.347	1.000
	Covariances	PED	.008	-1.056E-005	-.006	-.013	-.001	-1.783E-005	.000	.012
		CATINCOM	-1.056E-005	.003	.000	1.922E-005	.001	.000	-.001	.000
		SWYHBSDL	-.006	.000	.013	.013	.002	-.002	-.001	-.012
		HODYVL	-.013	1.922E-005	.013	.046	.002	-.009	.002	-.030
		NFMA	-.001	.001	.002	.002	.007	-.002	-.002	.003
		NFMB	-1.783E-005	.000	-.002	-.009	-.002	.011	.002	.002
		FEDLHH	.000	-.001	-.001	.002	-.002	.002	.004	-.004
		OCC	.012	.000	-.012	-.030	.003	.002	-.004	.032

a. Dependent Variable: VOLDON

Collinearity Diagnostics[a]

Model	Dimension	Eigen value	Condition Index	Variance Proportions								
				(Constant)	HODYVL	CATINCOM	SWYHBSDL	NFMB	NFMA	FEDLHH	OCC	PED
1	1	8.212	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	.428	4.382	.00	.00	.00	.00	.01	.01	.03	.01	.04
	3	.133	7.846	.00	.00	.00	.01	.05	.15	.16	.02	.00
	4	.082	10.034	.00	.00	.03	.26	.10	.05	.01	.00	.10
	5	.057	12.040	.00	.00	.59	.02	.18	.08	.01	.01	.01
	6	.038	14.686	.00	.00	.13	.34	.15	.04	.07	.07	.25
	7	.036	15.134	.01	.00	.01	.04	.40	.33	.65	.03	.02
	8	.013	24.989	.11	.02	.23	.00	.00	.31	.06	.34	.20
	9	.001	78.724	.89	.97	.01	.33	.11	.04	.02	.50	.38

a. Dependent Variable: VOLDON

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.9244	3.2973	2.3350	.16476	400
Residual	-1.61118	2.93818	.00000	1.12421	400
Std. Predicted Value	-2.492	5.840	.000	1.000	400
Std. Residual	-1.419	2.587	.000	.990	400

a. Dependent Variable: VOLDON

R Square value of .021 shows that the data varies by a factor of 2.10% whereas the value of F as per covariance table remained at and around 0.005 indicates the significance of the variance and thus it can be inferred that the hypothesis people are willing to pay cannot be rejected. Moreover, Pearson's correlation coefficient recorded positive relationship between Formal Education Level of the head of the family (FEDLHH) and Occupation (OCC) with Pollution and Environmental Degradation (PED) which means that irrespective of the income category, frequency of visits, family size etc education and occupation is significantly influencing the awareness with regard to environment.

Compulsory tax

Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.138[a]	.019	-.001	1.08816	.019	.946	8	391	.478

a. Predictors: (Constant), OCC, CATINCOM, NFMB, SWYHBSDL, NFMA, HODYVL, FEDLHH, PED

b. Dependent Variable: VPOCTAX

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	**Regression**	8.961	8	1.120	.946	.478[b]
	Residual	462.976	391	1.184		
	Total	471.938	399			

a. Dependent Variable: VPOCTAX

b. Predictors: (Constant), OCC, CATINCOM, NFMB, SWYHBSDL, NFMA, HODYVL, FEDLHH, PED

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	**(Constant)**	3.486	.957		3.644	.000			
	PED	.073	.086	.091	.851	.395	-.064	.043	.043
	CATINCOM	-.008	.051	-.008	-.158	.875	-.012	-.008	-.008
	SWYHBSDL	-.003	.109	-.002	-.030	.976	.062	-.002	-.002
	HODYVL	-.281	.206	-.128	-1.361	.174	-.037	-.069	-.068
	NFMA	.023	.081	.020	.290	.772	-.050	.015	.015
	NFMB	-.079	.102	-.051	-.773	.440	-.077	-.039	-.039
	FEDLHH	-.074	.057	-.099	-1.293	.197	.022	-.065	-.065
	OCC	.294	.172	.239	1.705	.089	.081	.086	.085

a. Dependent Variable: VPOCTAX

Coefficient Correlations[a]

Model			OCC	CATINCOM	NFMB	SWYHBSDL	NFMA	HODYVL	FEDLHH	PED
1	Correlations	OCC	1.000	.031	.126	-.566	.211	-.762	-.347	.761
		CATINCOM	.031	1.000	-.077	.035	.112	.002	-.180	-.002
		NFMB	.126	-.077	1.000	-.180	-.232	-.380	.239	-.002
		SWYHBSDL	-.566	.035	-.180	1.000	.194	.530	-.169	-.553
		NFMA	.211	.112	-.232	.194	1.000	.105	-.481	-.137
		HODYVL	-.762	.002	-.380	.530	.105	1.000	.147	-.655
		FEDLHH	-.347	-.180	.239	-.169	-.481	.147	1.000	.035
		PED	.761	-.002	-.002	-.553	-.137	-.655	.035	1.000
	Covariances	OCC	.030	.000	.002	-.011	.003	-.027	-.003	.011
		CATINCOM	.000	.003	.000	.000	.000	1.764E-005	-.001	-9.692E-006
		NFMB	.002	.000	.010	-.002	-.002	-.008	.001	-1.637E-005
		SWYHBSDL	-.011	.000	-.002	.012	.002	.012	-.001	-.005
		NFMA	.003	.000	-.002	.002	.007	.002	-.002	-.001
		HODYVL	-.027	1.764E-005	-.008	.012	.002	.043	.002	-.012
		FEDLHH	-.003	-.001	.001	-.001	-.002	.002	.003	.000
		PED	.011	-9.692E-006	-1.637E-005	-.005	-.001	-.012	.000	.007

a. Dependent Variable: VPOCTAX

Collinearity Diagnostics[a]

Model	Dimension	Eigen value	Condition Index	Variance Proportions								
				(Constant)	PED	CATINCOM	SWYHBSDL	HODYVL	NFMA	NFMB	FEDLHH	OCC
1	1	8.212	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	.428	4.382	.00	.04	.00	.00	.00	.01	.01	.03	.01
	3	.133	7.846	.00	.00	.00	.01	.00	.15	.05	.16	.02
	4	.082	10.034	.00	.10	.03	.26	.00	.05	.10	.01	.00
	5	.057	12.040	.00	.01	.59	.02	.00	.08	.18	.01	.01
	6	.038	14.686	.00	.25	.13	.34	.00	.04	.15	.07	.07
	7	.036	15.134	.01	.02	.01	.04	.00	.33	.40	.65	.03
	8	.013	24.989	.11	.20	.23	.00	.02	.31	.00	.06	.34
	9	.001	78.724	.89	.38	.01	.33	.97	.04	.11	.02	.50

a. Dependent Variable: VPOCTAX

Residuals statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.9973	3.0983	2.3125	.14987	400
Residual	-1.68267	2.88906	.00000	1.07719	400
Std. Predicted Value	-2.103	5.244	.000	1.000	400
Std. Residual	-1.546	2.655	.000	.990	400

a. Dependent Variable: VPOCTAX

R Square value of .019 computed for the compulsory tax payment taken as dependent variable shows that the data varies by a factor of 1.90%. However, the value of F as per covariance table remained almost at and around 0.005 indicating thereby the significance of the variance and thus it can be inferred that the hypothesis people are willing to pay cannot be rejected. Moreover, Pearson's correlation coefficient recorded positive relationship between Occupation (OCC), Category of Income (CATINCOM) and family size (NFMB and NFMA) with Pollution and Environmental Degradation (PED) which means that irrespective of the frequency of visits, residence time (SWYHBSDL), Formal Education level (FEDLHH) etc occupation is significantly influencing the awareness with regard to environment and payment of compulsory tax for the improved environmental services.

Coefficients of VOLDON with Occupation

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.075[a]	.006	.003	1.13446	.006	2.241	1	398	.135

a. Predictors: (Constant), OCC

b. Dependent Variable: VOLDON

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	**Regression**	2.885	1	2.885	2.241	.135[b]
	Residual	512.225	398	1.287		
	Total	515.110	399			

a. Dependent Variable: VOLDON
b. Predictors: (Constant), OCC

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	**(Constant)**	2.143	.140		15.259	.000			
	OCC	.096	.064	.075	1.497	.135	.075	.075	.075

Collinearity Diagnostics[a]

Model	Dimension	Eigen value	Condition Index	Variance Proportions	
				(Constant)	OCC
1	1	1.915	1.000	.04	.04
	2	.085	4.740	.96	.96

a. Dependent Variable: VOLDON

Residuals statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.2388	2.5273	2.3350	.08503	400
Residual	-1.43115	2.76115	.00000	1.13304	400
Std. Predicted Value	-1.131	2.262	.000	1.000	400
Std. Residual	-1.262	2.434	.000	.999	400

a. Dependent Variable: VOLDON

Correlations

		VOLDON	VPOCTAX	OCC
VOLDON	Pearson Correlation	1	.071	.075
	Sig. (2-tailed)		.155	.135
	N	400	400	400
VPOCTAX	Pearson Correlation	.071	1	.081
	Sig. (2-tailed)	.155		.107
	N	400	400	400
OCC	Pearson Correlation	.075	.081	1
	Sig. (2-tailed)	.135	.107	
	N	400	400	400

In fact, occupation determining income also recorded insignificant correlation with voluntary donations and compulsory tax payment. Moreover, as per the model summary R square value of .006 indicates that VOLDON and OCC do not show significant correlation and the hypothesis that voluntary donations depend upon the occupation is henceforth rejected.

Coefficient of VOLDON with FEDLHH

Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.025[a]	.001	-.002	1.13730	.001	.243	1	398	.622

a. Predictors: (Constant), FEDLHH

b. Dependent Variable: VOLDON

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	**Regression**	.315	1	.315	.243	.622[b]
	Residual	514.795	398	1.293		
	Total	515.110	399			

a. Dependent Variable: VOLDON

b. Predictors: (Constant), FEDLHH

Coefficient

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	2.399	.142		16.912	.000			
	FEDLHH	-.019	.039	-.025	-.493	.622	-.025	-.025	-.025

a. Dependent Variable: VOLDON

Collinearity diagnostics[a]

Model	Dimension	Eigen value	Condition Index	Variance Proportions	
				(Constant)	FEDLHH
1	1	1.916	1.000	.04	.04
	2	.084	4.780	.96	.96

a. Dependent Variable: VOLDON

Residuals statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.3020	2.3797	2.3350	.02808	400
Residual	-1.37968	2.69802	.00000	1.13588	400
Std. Predicted Value	-1.176	1.591	.000	1.000	400
Std. Residual	-1.213	2.372	.000	.999	400

a. Dependent Variable: VOLDON

Correlations

		VOLDON	VPOCTAX	FEDLHH
VOLDON	Pearson Correlation	1	.071	-.025
	Sig. (2-tailed)		.155	.622
	N	400	400	400
VPOCTAX	Pearson Correlation	.071	1	.022
	Sig. (2-tailed)	.155		.668
	N	400	400	400
FEDLHH	Pearson Correlation	-.025	.022	1
	Sig. (2-tailed)	.622	.668	
	N	400	400	400

As a matter of fact, education level recorded positive but least significant correlation with compulsory tax payment and voluntary donations. Even model summary with R square value of .001 and P value of 0.622 indicates that the data varies by a factor of 0.1% which means that the data varies by minor numeral number and thus reinforce the observation.

Coefficient of VOLDON with CATINCOM

Model summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.019[a]	.000	-.002	1.13744	.000	.145	1	398	.704

a. Predictors: (Constant), CATINCOM

b. Dependent Variable: VOLDON

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	**Regression**	.188	1	.188	.145	.704[b]
	Residual	514.922	398	1.294		
	Total	515.110	399			

a. Dependent Variable: VOLDON

b. Predictors: (Constant), CATINCOM

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	**(Constant)**	2.427	.249		9.760	.000			
	CATINCOM	-.020	.052	-.019	-.381	.704	-.019	-.019	-.019

a. Dependent Variable: VOLDON

Coefficient Correlations[a]

Model			CATINCOM
1	Correlations	CATINCOM	1.000
	Covariances	CATINCOM	.003

a. Dependent Variable: VOLDON

Collinearity Diagnostics[a]

Model	Dimension	Eigen value	Condition Index	Variance Proportions	
				(Constant)	CATINCOM
1	1	1.973	1.000	.01	.01
	2	.027	8.629	.99	.99

a. Dependent Variable: VOLDON

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.3077	2.4073	2.3350	.02168	400
Residual	-1.40726	2.69227	.00000	1.13602	400
Std. Predicted Value	-1.258	3.333	.000	1.000	400
Std. Residual	-1.237	2.367	.000	.999	400

a. Dependent Variable: VOLDON

Correlations

		VOLDON	VPOCTAX	CATINCOM
VOLDON	Pearson Correlation	1	.071	-.019
	Sig. (2-tailed)		.155	.704
	N	400	400	400
VPOCTAX	Pearson Correlation	.071	1	-.012
	Sig. (2-tailed)	.155		.808
	N	400	400	400
CATINCOM	Pearson Correlation	-.019	-.012	1
	Sig. (2-tailed)	.704	.808	
	N	400	400	400

In fact, income has been observed to share an insignificant correlation with both voluntary donations and compulsory tax payment as has been observed for the above-mentioned parameters. And model summary with R square value of .000 and P value of 0.704 support the said observation. As a matter of fact, Badola and Hussain (2003) reported that the attitude of the people twards conservation and related issues is influenced by demographic and socio-economic conditions of the people.

People demonstrated their willingness to pay more for the development and conservation of the lake while receiving superior recreational and aesthetic amenities at discounted rates. Although income category influenced their contribution as voluntary donations and compulsory tax (Table 93). The payment options of Rs 250-500 and 1-250 respectively were chosen by the majority of the people, and (18.5%) of the people opted for 501-1000 for the improved services of the lake. However, unlike voluntary donations in response to enhanced services, respondents expressed dissatisfaction with the required tax for lake development, which was paid without reduction. (68.4%) 0f the people were willing to pay compulsory tax in the wake of improved services and (31.6%) showed non willingness (Table 94). The total voluntary payment of compulsory tax was 59660.4/= (Table 95) and the preferred mode of payment was biannually (Table 96). Likewise, Whitehead (1990) recorded mean willingness to pay to vary from \$6.31 to \$12.67 per household. (70%) of the people said that they will make reductions in personal expenditure and the (30%) of the people said they will curtail domestic expenditure to make payment (Table 97).

Table 93 Amount to be paid for restoration of Dal Lake voluntarily (WTP).

S. No.	Option of Payment	Percentage	Amount
1	1– 250	24.8	3112.4
2	251 – 500	39.6	14850.0
3	501 – 1000	18.5	14884.2
4	1001 – 2000	11.3	16955.6
5	2000-2500	5.8	13050
Total		100.0	**62,852.2**

Table 94 WTP in the wake of improved services with discount.

Willingness to Pay	Percentage
Yes	68.4
No	31.6

Table 95 Voluntary payment of compulsory tax.

Payment Option	Rank (%)	Amount (Rs)
1 – 250	24.8	3112.4
251 – 500	38.7	14531.8
501 – 1000	21.0	15760.5
1001 – 2000	11.5	17255.7
2000- 2500	4.0	9000
Total	100.0	**59,660.4**

Table 96 Preferred timing of payment.

S. No.	Timing of Payment	Percentage
1	**Monthly**	31.3
2	**Biannually**	49.4
3	**Yearly**	19.3

Table 97 Reduction in the monthly budget in order to make payment.

S. No.	Type of Curtailment	Percentage
1	**Curtail Personal Expenditures**	70.5
2	**Curtail Domestic Expenditures**	29.5

People urged the inclusion of entry fees because of the lake's potential for producing revenue, even though as of now there is no provision for gate fees, (70.9) were in favour of gate fee and (29.1) percent of participants were un willing (Table 98).In the case of Khao Yai National Park, a research conducted by TDRI/HIID found that the WTP for an admission fee is 22 baht, but the park currently charges only 5 baht per visitor (Kaosa-ard et al., 1995).

Although the installation of a gate fee at Dal Lake would create cash for the lake, certain stipulations regarding the distribution aspect of entrance fees, such as granting free admission to school and university students or a 50% discount to senior residents, must be addressed. These safeguards would ensure that people from all socioeconomic backgrounds may visit the lake. Majority of the people said the gate fee should be in the range of 10-20 rupees (Table 99).

Table 98 Implementation of gate fee at Dallake.

S. No.	Can pay Gate Fee	Percentage
1	**Yes**	70.9
2	**No**	29.1

Table 99 Amount to be fixed as gate fee.

S. No.	Option of Payment	Percentage	Amount
1	**Re 1 – Rs 5**	3.7	11.1
2	**Rs 6 – Rs 10**	17.5	140
3	**Rs 10 – Rs 20**	54.0	810
4	**Rs 21 – Rs 50**	15.3	543.15
5	**Above Rs 50**	9.5	665

Total	100.0	**2169.25**

The following tables summarize the other significant aspects of the current CVM investigation. People were asked to rate several challenges confronting the country as part of the survey, and the majority of those polled gave the most weightage to the lack of a stable administration, followed by corruption, pollution/environmental degradation, foreign infiltration, and economic issues. Only 7.5 percent of respondents ranked environmental degradation as the least important issue. When citizens were questioned about the country's environmental challenges, however, the majority of people prioritized solid waste pollution, followed by industrial pollution, deforestation, vehicular and noise pollution (Table 100,101).

Table 100 Ranking of problems facing the country.

Problems	%age	%age	%age	%age	%age
Corruption	34.0	66	Nil	Nil	Nil
Foreign infiltration	59.0	25.4	7.8	7.8	Nil
Pollution / Environmental Degradation	7.5	63.0	0.0	7.0	22.5
Lack of a Stable Government	35.3	7.5	50.3	0.0	7.0
Economic Issues	20.8	40.0	3.8	7.8	27.6

Table 101 Ranking of environmental problems.

Problems	Percentage				
Deforestation	10.6	36.3	20.3	19.0	13.8
Solid Waste Pollution	29.2	24.5	18.3	9.0	19.0
Noise Pollution	27.0	16.5	46.0	10.5	Nil
Vehicular Pollution	7.0	26.5	25.3	41.2	Nil
Industrial Pollution	43.0	32.5	24.5	Nil	Nil

Of all the people who were interviewed during the present study, Maximum of the people got drinking water supplied by tube wells and Jal Shakti Dept. of Jammu and Kashmir (Table 102). During the current study it was found that that about 5.7 million gallons of water are extracted from Dal Lake on daily basis in order to meet the demands of about 1,80,000 people.

Table 102 Sources of drinking water.

S. No.	Source of Water	Percentage (%)
1	**PHE Supply**	20.2
2	**Tube Wells**	50.0
3	**Tankers**	7.8
4	**Other Sources**	22.0

People living near the lake appear to be unaware of the precautionary measures required to make the water safer to drink, as only 16.5 percent people used aqua guards and 15.5 percent used chlorine tablets and alum for purification. However, 53.4 percent people said they were using boiled water to prevent the spread of diseases (Table 103). This ignorance cost them a lot of money every year, as discussed previously in the Cost of Illness Approach.

Table 103 Appliances used for purification of water.

S. No.	Purification Techniques	Rank (%)
1	**Aquaguard**	16.5
2	**Zero B**	3.8
3	**Ordinary Filter**	10.8
4	**Chlorine / Alum**	15.5
5	**Boil Water**	53.4
6	**None**	0.0

However, when it comes to the lake's importance, people place a strong voice on its preservation. 50.3 percent strongly agreed with our broad opinion that the Dal Lake merits special conservation efforts, 23.8 percent simply remained neutral, and the 3.6 percent strongly disagreed with our viewpoint (Table 104).

Table 104 Requirement of special conservation measures for Dal Lake.

S. No.	Environmental Concern	Rank (%)
1	**Strongly Agree**	22.3
2	**Agree**	50.3
3	**Neutral**	23.8
4	**Disagree**	0
5	**Strongly Disagree**	3.6

The most significant service offered by Dal Lake, as compared to other services, was the recreation and tourism, as 59% of the people responded it as most important. Employment and stability of micro-climate followed (Table 105). This survey also reflects, to some part, the government's careless attitude toward this environmental resource, which requires development in order to become a sought-after tourist destination.

Table 105 Services provided by the Dallake and their ranking.

Services	**Percentage**				
Drinking water	40.0	41.7	18.3	0.0	0.0
Stability of Microclimate	56.5	43.5	0.0	0.0	0.0
Employment	58.0	25.3	16.7	0.0	0,0
Recreation and Tourism	59.0	27.3	13.7	0.0	0.0

People appear to be divided on the question of risks to the lake's very existence, with washing and bathing, deforestation, agricultural waste, siltation, sewage, growing population, encroachment and weeds, and eutrophication all receiving almost equal weight. A large majority of individuals voted boating, washing and bathing as the least important threats (Table 106).

Table 106 Ranking of threats to the Dallake.

Threats	**Percentage**				
Siltation	3.8	43.3	24.3	13.8	14.8
Solid Waste	3.8	47.4	13.8	-	35.0
Sewage	11.3	31.6	16.8	13.8	26.5
Encroachment	27.6	15.3	33.3	16.8	7.0
Increased Population	13.3	21.5	28.3	11.3	25.6
Weeds and Eutrophication	17.0	19.0	26.7	14.3	23.0
Boating	13.2	7.5	24.3	28.3	26.7
Agricultural waste	17.0	28,0	11.5	36.5	7.0
Deforestation	7.5	9.5	25.5	38.5	19.0
Ill planned Development	0.0	44.0	31.7	24.3	0.0
Washing and Bathing	0.0	57.3	23.6	5.3	3.8

Regarding socio-economic features, the premier question asked was the occupation of the people interviewed and majority of the people were private sector employees (38.4%) and (25.8%) were in the Govt. service (Table 107).

Table 107 Occupation of the respondents.

S. No.	Occupation	Percentage (%)
1.	**Private Sector Employee**	38.4
2.	**Government Employee**	25.8
3.	**Self Employed**	35.8
4.	**Others (Please Specify)**	Nil

Since the state's literacy rate is over 63.18%, the majority of the respondents (33.2%) were undergraduates/graduates, followed by professionals (28.5%) and post graduates (16.5%). 10th grade and below, 12th grade, professionals, and others (Table 108).

Table 108 Formal education level of the head of the household or the respondents.

S. No.	Education Level	Percentage
1	**Below Class X**	21.8
2	**Upto Class XII**	Nil
3	**Undergraduate / Graduate**	33.2
4	**Post Graduate**	16.5
5	**Professional Qualification (B.E./ B. Tech./ M.B.A./ M.B.B.S.)**	28.5
6	**Others**	0.0

With maximum people in the private sector and Govt. employees about 39.5.% people were having gross annual income in the range of Rs 2 to Rs 3 lakh and 21.5% people were having income in the range of 3 to 5 lakh (Table 109).

Table 109 Households total gross income.

S. No.	Income Category	Percentage	Amount
1	**< Rs. 25,000**	1.0	25,000
2	**Rs. 25,000 – Rs 50,000**	3.5	131,250
3	**Rs. 50,000 – Rs 1 Lakh**	9.5	712,500
4	**Rs. 1 Lakh – Rs 2 Lakh**	25.0	3,750,000
5	**Rs. 2 Lakh – Rs. 3 Lakh**	39.5	9875000
6	**Rs. 3 Lakh – Rs. 5 Lakh**	21.5	8600000
Total		100.0	**23093750**

The majority of those interviewed had no minor family members, followed by those who had one or two minor family members. The majority of the families had 4-6 people, followed by 3-4, and 2-3 (Table 110,111).

Table 110 Number of house hold members below the age of 18.

S. No.	Number of Members	Percentage
1	**1**	18.5
2	**2 - 3**	48.0
3	**4 - 5**	33.5
4	**5 – 6**	0.0
5	**6 – 7**	0.0
6	**Nil**	0.0

Table 111 Number of house hold members above the age of 18

S. No.	Number of Members	Percentage
1	**2 – 3**	8.0
2	**3 – 4**	35.5
3	**4 – 5**	33.0
4	**5 – 7**	23.5
5	**7 - 10**	0.0

People interviewed appear to be less interested in visiting the lake, as the majority visited it within 1to 2 years, followed by those who visited it within 7-12 months. it is easy to deduce that people are unaware of the lake due to insufficient advertising by the state tourism authority (Table 112).

Table 112 Frequency of your visits to Dallake.

S. No.	Frequency of Visits	Percentage
1	**Once in a week**	0.0
2	**Once in a fortnight**	0.0
3	**Once in a month**	0.0
4	**Once in 2 – 6 months**	0.0
5	**Once in 7 – 12 months**	42.5
6	**Once in 1 – 2 years**	57.5

The majority of the people had been to Dal Lake 1-5 years (43.3%) and (40.7%) had been in 5-10 years (Table 113). In fact, period of residence has been observed to have a negative but significant relationship with both voluntary and compulsory tax payment. Correlation matrix is given in the (Table 114).

Table 113 Since when you have been staying at Dallake.

S. No.	Time in Years	Percentage
1	**Less than 1 year**	16.0
2	**1– 5 years**	43.3
3	**5 – 10 years**	40.7
4	**10 – 20 years**	0.0
5	**20 years and more**	0.0

Table 114 Correlation coefcients.

		VOLDON	VPOCTAX	SWUHSTS
VOLDON	Pearson Correlation	1	.071	.027
	Sig. (2-tailed)		.155	.585
VPOCTAX	Pearson Correlation	.071	1	.062
	Sig. (2-tailed)	.155		.218
SWUHSTS	Pearson Correlation	.027	.062	1
	Sig. (2-tailed)	.585	.218	

** Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

The majority of the respondents interviewed for this survey believed that their input would impact government decision-making (69.5%). While 30.5% of respondents were unsure about the survey's outcome (Table 115).

Table 115 Impact of your answers in the descision making on Dallake.

S. No.	Response	Percentage
1	**Yes**	69.5
2	**No**	30.5
3	**Perhaps**	0.0

The vast majority of those questioned were split on whether or not they would be required to pay for the lake's renovation. About 77.5 percent thought it was likely to happen, while 22.5 percent did not believe the supposition (Table 116).

Table 116 Your role in the improvement process of Dallake.

S. No.	Response	Percentage
1	**Yes**	77.5
2	**No**	22.5
3	**Perhaps**	0.0

6.6.8. Hedonic pricing

This method is used to find out the relationship between ecosystem service and the corresponding property values. The main idea of the hedonic pricing is that the price of any environmental service is determined by its features or services.

The goal of this assessment study was to uncover the elements that influence property prices near and far from the lake. The attitude of the people regarding the priority that they assign while buying a particular piece of property was analyzed in order to determine the same. Apart from that, various property values in specific places in and around the city were collected, and these areas were then graded based on factors such as closeness to markets, access, environment and the presence or absence of the lake view.

To arrive at the appraisal scores given to distinct components, the values linked to various factors relating property were evaluated using SPSS 12.0. (Table 117) shows the appraisal scores received as a result of this process. Table 90 demonstrates that, of all the categories, proximity to lake came out on top (65.3%), followed by hospital| nursing home (65.0%) and then drinking water (59.5%) as the most important considerations when purchasing a home. Since the union territory of Jammu and Kashmir is a land locked and has difficult terrain besides disturbance in the valley from last twenty years is the main factor which prevents people to buy property here. Furthermore, when it comes to the many variables evaluated by a prospective buyer when purchasing a new property, the existence of a children's school, major highways, and other amenities in the neighborhood of the property are kept in mind besides the presence of Lake.

Table 117 Ranking of various factors while buying property.

Factors	Rank 1 (%)	Rank 2 (%)	Rank 3 (%)	Rank 4 (%)	Rank 5 (%)
Market place	21.0	38.5	11.3	29.3	-
Place of work	26.5	65.8	7.8	-	-
Major Highways	45.5	40.0	14.5	-	-
Children's School	51.0	18.8	30.3	-	-
Proximity to Lake	65.3	25.8	9.0	-	-
Hospital/Nursing Home	65.0	27.5	7.5	-	-
Quality of Construction	19.3	70.0	10.8	-	-
Age of House	15.5	58.5	15.3	10.8	-
Housing density	15.5	32.5	48.3	3.8	-
Air pollution	-	14.8	34.3	51.0	-
Level of Noise Pollution	11.3	27.5	13.8	34.3	13.3
Proximity to Park	-	47.0	32.8	16.5	3.8
Availability of Household help	3.8	47.3	23.3	22.0	3.8
Drinking water	59.5	29.8	7.0	-	3.8

With the improvement in situation, the property prices have increased ten to twenty times in the vicinity of lake. Feather et al. (1992) also found that property prices are influenced by the scenic beauty of the Lake, front location and size of the Lake

To express the various factors affecting property prices in the city, following regression equation was used:

$P = \alpha + \beta_1 NEIGHBOURHOOD + \beta_2 MARKET + \beta_3 ACCESS + \beta_4 LAKE + \beta_5 ENVIRONMENT + \beta_6 HOUSING\ DENSITY$

Where P = property price in Rs/sq.ft.

Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.142[a]	.020	.008	.80435	.020	1.624	5	394	.153

a. Predictors: (Constant), GAPL, PTL, PTMH, HD, PTPOW

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	**Regression**	5.253	5	1.051	1.624	.153[b]
	Residual	254.907	394	.647		
	Total	260.160	399			

a. Dependent Variable: PPPSF

b. Predictors: (Constant), GAPL, PTL, PTMH, HD, PTPOW

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	1.424	.301		4.725	.000			
	PTPOW	-.157	.118	-.108	-1.332	.184	.011	-.067	-.066
	PTMH	-.050	.061	-.044	-.829	.408	-.067	-.042	-.041
	PTL	.010	.074	.008	.130	.897	.014	.007	.006
	HD	-.132	.068	-.129	-1.939	.053	-.035	-.097	-.097
	GAPL	.181	.080	.163	2.259	.024	.085	.113	.113

It is clear from the table above that all of the coefficients are significant. Furthermore, partial correlation tests were used to determine the difference in property prices near and far from the lake, with the result coming out to be 0.142 after correcting for all other variables. As a result, the difference in property price for a property near the lake would be about 14.2 percent. To put it another way, a location away from the lake would cost 14.2 percent less than a property close to the lake. Knetsch (1964), David (1968), Brown and Pollakowski (1977), Darling (1973), Reynolds et al. (1973), Young and Teti (1984), Feather et al. (1992), and Lansford and Jones (1995), are only a few of the studies that have been published for the increase in property values near lakes.

6.6.9. Multiple uses of Dal Lake to mulitple stakeholders

Dal Lake was found to provide a variety of benefits to the various stakeholders who live near the lake throughout the current investigation. The following table summarizes the numerous values that have been estimated thus far using various valuation techniques:

Table 118 Summary of the values as determined through various valuation techniques.

S. No.	Uses	Stakeholders	Valuation Technique	Price (Rs)
A.	Drinking Water facility	PHE Department	Supply Cost	68941200/-
B.	Boating (Shikaras)	Boatmen	Income Estimation	3,1100000/-
C.	Secondary activities 1. Cold drinks and Ice cream 2. Tea Stall 3. Golegappa/Panipuri Selling	 Individual owner Individual owner Golegappa seller	 Income Estimation Income Estimation Income Estimation	 240000000/- 7000000/- 2000000/-
D.	Water Borne Diseases	Population using lake water	Cost of Illness Approach	7604250/-
E	Handicrafts	Handicraft seller	Income Estimation	35000000/-
F	Shopping Complexes	Salesmen	Income Estimation	42000000/-
G	Public Parks	Floriculture Dept.	Income Estimation	720000/-
H	Public Toilets	SMC	Income Estimation	18900000/-
I	Nadroo Harvesting	Hanji	Income Estimation	138600000/-
J	Haakh	Hanji	Income Estimation	17280000/-
K	Raddish and Turnip	Hanji	Income Estimation	273000/-
L	Bottle gourd and cucumber	Hanji	Income Estimation	1800000/-
M	Tomato	Hanji	Income Estimation	270000/-
N	Carrot	Hanji	Income Estimation	280000/-
O	Brinjal	Hanji	Income Estimation	360000/-
P	Spinach	Hanji	Income Estimation	1800000/-
Q	Capsicum	Hanji	Income Estimation	300000/-
R	Bhindi	Hanji	Income Estimation	162000/-
S	Dhania	Hanji	Income Estimation	90000/-
T	Spring Onion	Hanji	Income Estimation	120000/-
U	Trapa	Hanji	Income Estimation	504000/-
V	Increase in the price of property	Front side property owners	Hedonic Pricing method	14.2% per square feet

As can be seen from the preceding facts, the PHE Department earns significantly from the extraction of water from the Dal Lake which is supplied to the city areas for drinking purposes after treatment. Furthermore, people who engage in hanji activity earn huge amount of money to the tone of Rs **16,18,66,000 per** year (Table 118), similar results were observed by (Mukherjee et al., 2012) for Chilika lake in Odisha. The prevalence of water-borne infections among persons who drink lake water reflects the overall health of the water body. People's desire to pay for pure water is reflected in the cost of avoiding disease, money spent on Medicare, money foregone for recovery from illness, and water purifying expenditures faced by them. In fact, people place higher value on the property near the lake, and the difference in property prices near and far from the lake is around 14.2 percent per square feet. People expressed their willingness to donate to the development and conservation of the lake because the entire population uses it for enjoyment. People record their willingness to pay for conserving the lake and improving recreational benefits, as well as spending a lot of money for visiting the lake and on recreation, as well as recovering from and avoiding illness acquired from drinking lake water. However, the total economic cost of the Dal Lake cannot be calcullated in its entirety because certain existence values cannot be computed, such as the value of the lake for stabilizing microclimate of the area and ground water recharge. The current exercise so clearly demonstrates the people's major reliance on the lake, since it serves as a source of potable water and a source of fodder for a number of stakeholders residing in its close vicinity, as well as providing employment opportunities through increased tourism. People demonstrated a high level of knowledge regarding the various risks facing the lake, as well as a readiness to pay for the effective management of this aquatic resource, indicating the necessity to root out the same for the long-lasting sustainable management of this water body. The profile of the tourists who visited Dal Lake and pariicipated in survey is given in (Table 119)

Filled Sample Questionnaire of TCM

DEPARTMENT OF BOTANY

School of bioengineering and biosciences

Lovely Professional University, Jalandhar

TRAVEL COST QUESTIONNAIRE FOR DAL LAKE

We are carrying out a survey for which we need to ask you a few questions. It will take around 15 minutes. The answer that you may provide may be used by policy makers in their decision-making.

1. Respondents Name: Mr./Mrs/Ms......Dinesh Ahir.......................

2. Address ....43..Lions.......Nagar..........Bhuj....Gujarat.......

Telephone...

3. Occupation

1. Private Sector Employee
2. Government Employee
3. ✓ Self Employed
4. Others (Please Specify)..

4. Formal Education Level of the Head of the Household or the Respondent.

1. Below Class X
2. Upto Class XII
3. ✓ Undergraduate / Graduate
4. Post Graduate
5. Professional Qualification (B.E./ B. Tech./ M.B.A./ M.B.B.S.)
6. Others (Please Specify)...

5. Please tell me the category, which include you and your household's total gross annual income from all sources for the last year (i.e., 2004 – 2005).

1. < Rs. 25,000
2. Rs. 25,000 – Rs 50,000
3. Rs. 50,000 – Rs 1 Lakh
4. Rs. 1 Lakh – Rs 2 Lakh
5. Rs. 2 Lakh – Rs. 3 Lakh
6. ✓ Rs. 3 Lakh – Rs. 5 Lakh

6. Number of household members below the age of 18 years

1. 1
2. ✓ 2 - 3
3. 4 - 5
4. 5 – 6
5. 6 – 7
6. Nil

7. Number of household members above the age of 18 years

1. 2 – 3
2. ✓ 3 – 4
3. 4 – 5
4. 5 – 7
5. 7 - 10

7. How often do you visit the Dal Lake?

1. Once in a week
2. Once in a fortnight
3. Once in a month
4. Once in 2 – 6 months
5. Once in 7 – 12 months
6. Once in 1 – 2 years

8. Do you visit Dal Lake for recreational purposes like Boating, Rafting etc.?
1. Yes
2. No

9. What was your mode of travel?
1. Private Car/Tempo
2. Contract Car
3. Contract Bus
4. Local Bus
5. Train / Air

10. How many days you and your family members took to prepare for this trip?
1. 0 – 1 days
2. 1 – 2 days
3. 2 – 3 days
4. 3 – 4 days
5. 4 – 5 days

11. Wages incurred for the preparation of this trip?
1. < Rs 100
2. Rs. 100 – Rs 250
3. Rs. 250 – Rs 500
4. Rs. 500 – Rs 750
5. Rs 750 – Rs 1000
6. > Rs 1000

12. How much money you spent on fuel / paid as travelling fares for visiting the Dal Lake?
1. Rs 10 – Rs 50
2. Rs 50 – Rs 100
3. Rs 100 – Rs 250
4. Rs 250 – Rs 500
5. Rs 500 – Rs 1000
6. Rs 1000 – Rs 2000

13. How much you spent for Boarding and Lodging?
1. Rs 50 – Rs100
2. Rs 200 – Rs 500
3. Rs 500 – Rs 750
4. Rs 750 – Rs 1000
5. Rs 1000 – Rs 2000
6. > Rs 2000

14. How much you spent on Food and Snacks?
1. Rs 100 – Rs 250
2. Rs 250 – Rs 500
3. Rs 500 – Rs 750

4. Rs 750 – Rs 1000
5. Rs 1000 – Rs 1500
6. > Rs 1500

15. How much you spent on Beverages?
1. Rs 50
2. Rs 50 – Rs 100
3. Rs 100 – Rs 200
4. Rs 200 – Rs 500
5. Rs 500 – Rs 1000
6. > Rs 1000

16. How much you spent on Boating and Rafting?
1. Rs 10 – Rs 50
2. Rs 50 – Rs 100
3. Rs 100 – Rs 150
4. Rs 150 – Rs 200
5. Rs 250 – Rs 500
6. Rs 500 – Rs 750

17. How much money you intended/expected to spend on this trip?
1. < Rs 100
2. Rs 100 – Rs 500
3. Rs 500 – Rs 1000
4. Rs 1000 – Rs 2000
5. Rs 2000 – Rs 3500
6. > Rs 4000

18. How much money you actually spend on this trip?
1. < Rs 100
2. Rs 100 – Rs 500
3. Rs 500 – Rs 1000
4. Rs 1000 – Rs 2000
5. Rs 2000 – Rs 3500
6. > Rs 4000

19. Which of the following factors influence you to visit Dal Lake?
1. Religious / Sacred Place
2. Scenic Beauty
3. Recreation and Relaxation Purposes
4. Picnic Purposes

20. Which of the following factors hamper your visit Dal Lake?
1. Poor Roads
2. Security Concerns
3. Lack of Basic Facilities
4. Landslides

Dinesh Aabi
Sign. Of the Enumerator

DEPARTMENT OF BOTANY

School of bioengineering and biosciences

Lovely Professional University, Jalandhar

TRAVEL COST QUESTIONNAIRE FOR DAL LAKE

We are carrying out a survey for which we need to ask you a few questions. It will take around 15 minutes. The answer that you may provide may be used by policy makers in their decision-making.

1. Respondents Name: Mr./Mrs/Ms.........Anees Kumar Singh..........
2. Address ....Ranchi: Jarkhand.........
   Telephone.........8077910042.........
3. Occupation
   1. Private Sector Employee
   2. Government Employee
   3. Self Employed
   4. Others (Please Specify)....................
4. Formal Education Level of the Head of the Household or the Respondent.
   1. Below Class X
   2. Upto Class XII
   3. Undergraduate / Graduate
   4. Post Graduate
   5. Professional Qualification (B.E./ B. Tech./ M.B.A./ M.B.B.S.)
   6. Others (Please Specify)....................
5. Please tell me the category, which include you and your household's total gross annual income from all sources for the last year (i.e., 2004 – 2005).
   1. < Rs. 25,000
   2. Rs. 25,000 – Rs 50,000
   3. Rs. 50,000 – Rs 1 Lakh
   4. Rs. 1 Lakh – Rs 2 Lakh
   5. Rs. 2 Lakh – Rs. 3 Lakh
   6. Rs. 3 Lakh – Rs. 5 Lakh
6. Number of household members below the age of 18 years
   1. 1
   2. 2 - 3
   3. 4 - 5
   4. 5 – 6
   5. 6 – 7
   6. Nil
7. Number of household members above the age of 18 years
   1. 2 – 3
   2. 3 – 4
   3. 4 – 5
   4. 5 – 7
   5. 7 - 10

7. How often do you visit the Dal Lake?

1. Once in a week
2. Once in a fortnight
3. Once in a month
4. Once in 2 – 6 months
5. Once in 7 – 12 months
6. Once in 1 – 2 years

8. Do you visit Dal Lake for recreational purposes like Boating, Rafting etc.?
    1. Yes
    2. No
9. What was your mode of travel?
    1. Private Car/Tempo
    2. Contract Car
    3. Contract Bus
    4. Local Bus
    5. Train / Air
10. How many days you and your family members took to prepare for this trip?
    1. 0 – 1 days
    2. 1 – 2 days
    3. 2 – 3 days
    4. 3 – 4 days
    5. 4 – 5 days
11. Wages incurred for the preparation of this trip?
    1. < Rs 100
    2. Rs. 100 – Rs 250
    3. Rs. 250 – Rs 500
    4. Rs. 500 – Rs 750
    5. Rs 750 – Rs 1000
    6. > Rs 1000
12. How much money you spent on fuel / paid as travelling fares for visiting the Dal Lake?
    1. Rs 10 – Rs 50
    2. Rs 50 – Rs 100
    3. Rs 100 – Rs 250
    4. Rs 250 – Rs 500
    5. Rs 500 – Rs 1000
    6. Rs 1000 – Rs 2000
13. How much you spent for Boarding and Lodging?
    1. Rs 50 – Rs100
    2. Rs 200 – Rs 500
    3. Rs 500 – Rs 750
    4. Rs 750 – Rs 1000
    5. Rs 1000 – Rs 2000
    6. > Rs 2000
14. How much you spent on Food and Snacks?
    1. Rs 100 – Rs 250
    2. Rs 250 – Rs 500
    3. Rs 500 – Rs 750

4. Rs 750 – Rs 1000
5. Rs 1000 – Rs 1500
6. > Rs 1500

15. How much you spent on Beverages?
1. Rs 50
2. Rs 50 – Rs 100
3. Rs 100 – Rs 200
4. Rs 200 – Rs 500
5. Rs 500 – Rs 1000
6. > Rs 1000

16. How much you spent on Boating and Rafting?
1. Rs 10 – Rs 50
2. Rs 50 – Rs 100
3. Rs 100 – Rs 150
4. Rs 150 – Rs 200
5. Rs 250 – Rs 500
6. Rs 500 – Rs 750

17. How much money you intended/expected to spend on this trip?
1. < Rs 100
2. Rs 100 – Rs 500
3. Rs 500 – Rs 1000
4. Rs 1000 – Rs 2000
5. Rs 2000 – Rs 3500
6. > Rs 4000

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1. < Rs 100
2. Rs 100 – Rs 500
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4. Rs 1000 – Rs 2000
5. Rs 2000 – Rs 3500
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19. Which of the following factors influence you to visit Dal Lake?
1. Religious / Sacred Place
2. Scenic Beauty
3. Recreation and Relaxation Purposes
4. Picnic Purposes

20. Which of the following factors hamper your visit Dal Lake?
1. Poor Roads
2. Security Concerns
3. Lack of Basic Facilities
4. Landslides

Anees.

Sign. Of the Enumerator

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School of bioengineering and biosciences

Lovely Professional University, Jalandhar

TRAVEL COST QUESTIONNAIRE FOR DAL LAKE

We are carrying out a survey for which we need to ask you a few questions. It will take around 15 minutes. The answer that you may provide may be used by policy makers in their decision-making.

1. Respondents Name: Mr./Mrs/Ms........Owais Ahmad........................

2. Address .....Dangerpora.....Shopian...

Telephone.........6005590533...

3. Occupation
   1. Private Sector Employee
   2. Government Employee
   3. Self Employed
   4. Others (Please Specify)...

4. Formal Education Level of the Head of the Household or the Respondent.
   1. Below Class X
   2. Upto Class XII
   3. Undergraduate / Graduate
   4. Post Graduate
   5. Professional Qualification (B.E./ B. Tech./ M.B.A./ M.B.B.S.)
   6. Others (Please Specify)...

5. Please tell me the category, which include you and your household's total gross annual income from all sources for the last year (i.e., 2020 – 2021).
   1. < Rs. 25,000
   2. Rs. 25,000 – Rs 50,000
   3. Rs. 50,000 – Rs 1 Lakh
   4. Rs. 1 Lakh – Rs 2 Lakh
   5. Rs. 2 Lakh – Rs. 3 Lakh
   6. Rs. 3 Lakh – Rs. 5 Lakh

6. Number of household members below the age of 18 years
   1. 1
   2. 2 - 3
   3. 4 - 5
   4. 5 – 6
   5. 6 – 7
   6. Nil

7. Number of household members above the age of 18 years
   1. 2 – 3
   2. 3 – 4
   3. 4 – 5
   4. 5 – 7
   5. 7 - 10

7. How often do you visit the Dal Lake?

1. Once in a week
2. Once in a fortnight
3. Once in a month
4. Once in 2 – 6 months
5. Once in 7 – 12 months
6. Once in 1 – 2 years

8. Do you visit Dal Lake for recreational purposes like Boating, Rafting etc.?
1. Yes
2. No

9. What was your mode of travel?
1. Private Car/Tempo
2. Contract Car
3. Contract Bus
4. Local Bus
5. Train / Air

10. How many days you and your family members took to prepare for this trip?
1. 0 – 1 days
2. 1 – 2 days
3. 2 – 3 days
4. 3 – 4 days
5. 4 – 5 days

11. Wages incurred for the preparation of this trip?
1. < Rs 100
2. Rs. 100 – Rs 250
3. Rs. 250 – Rs 500
4. Rs. 500 – Rs 750
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3. Rs 100 – Rs 250
4. Rs 250 – Rs 500
5. Rs 500 – Rs 1000
6. Rs 1000 – Rs 2000

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1. Rs 50 – Rs100
2. Rs 200 – Rs 500
3. Rs 500 – Rs 750
4. Rs 750 – Rs 1000
5. Rs 1000 – Rs 2000
6. > Rs 2000

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2. Rs 250 – Rs 500
3. Rs 500 – Rs 750

5

4. Rs 750 – Rs 1000
5. Rs 1000 – Rs 1500
6. > Rs 1500

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4. Rs 200 – Rs 500
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6. > Rs 1000

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3. Rs 100 – Rs 150
4. Rs 150 – Rs 200
5. Rs 250 – Rs 500
6. Rs 500 – Rs 750

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1. < Rs 100
2. Rs 100 – Rs 500
3. Rs 500 – Rs 1000
4. Rs 1000 – Rs 2000
5. Rs 2000 – Rs 3500
6. > Rs 4000

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1. < Rs 100
2. Rs 100 – Rs 500
3. Rs 500 – Rs 1000
4. Rs 1000 – Rs 2000
5. Rs 2000 – Rs 3500
6. > Rs 4000

19. Which of the following factors influence you to visit Dal Lake?
1. Religious / Sacred Place
2. Scenic Beauty
3. Recreation and Relaxation Purposes
4. Picnic Purposes

20. Which of the following factors hamper your visit Dal Lake?
1. Poor Roads
2. Security Concerns
3. Lack of Basic Facilities
4. Landslides

Owais

Sign. Of the Enumerator

Filled Sample Questionnaire of CVM

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LOVELY PROFESSIONAL UNIVERSITY, JALANDHAR

CONTINGENT VALUATION QUESTIONNAIRE FOR DAL LAKE

We are carrying out a survey for which we need to ask you a few questions. It will take around 15 minutes. The answer that you may provide may be used by policy makers in their decision-making.

1. Respondents Name: Mr./Mrs/Ms……Prasan Mukherjee……………

2. Address ………Mumbai………………………………………………………………

Telephone………………………………………………………………………………

3. Occupation
   1. Private Sector Employee
   2. Government Employee
   3. Self Employed
   4. Others (Please Specify)……………………………………………………………

4. Formal Education Level of the Head of the Household or the Respondent.
   1. Below Class X
   2. Upto Class XII
   3. Undergraduate / Graduate
   4. Post Graduate
   5. Professional Qualification (B.E./ B. Tech./ M.B.A./ M.B.B.S.)
   6. Others (Please Specify)……………………………………………………………

5. Please tell me the category, which include you and your household's total gross annual income from all sources for the last year (i.e., 2020 – 2021).
   1. < Rs. 25,000
   2. Rs. 25,000 – Rs 50,000
   3. Rs. 50,000 – Rs 1 Lakh
   4. Rs. 1 Lakh – Rs 2 Lakh
   5. Rs. 2 Lakh – Rs. 3 Lakh
   6. Rs. 3 Lakh – Rs. 5 Lakh

6. Number of household members below the age of 18 years
   1. 1
   2. 2 - 3
   3. 4 - 5
   4. 5 – 6
   5. 6 – 7
   6. Nil

7. Number of household members above the age of 18 years
   1. 2 – 3
   2. 3 – 4
   3. 4 – 5
   4. 5 – 7
   5. 7 - 10

7. How often do you visit the Dal Lake?

1

1. Once in a week
2. Once in a fortnight
3. Once in a month
4. Once in 2 – 6 months
5. Once in 7 – 12 months
6. Once in 1 – 2 years

8. Do you visit Dal Lake for recreational purposes like Boating, Rafting etc.?

1. Yes
2. No

9. Since when you have been staying at Dal?

1. Less than 1 year
2. 1 – 5 years
3. 5 – 10 years
4. 10 – 20 years
5. 20 years and more

10. How would you rank the following problems that the country is facing now according to their order of importance to you as person?

1. most important
2. very important
3. important
4. somewhat important
5. least important

Problems	Ranking
a) Corruption	2
b) Foreign Infiltration	2
c) Pollution / Environmental Degradation	2
d) Lack of a Stable Government	2
e) Economic Issues	2

11. How would rank the following problems:

1. most important
2. very important
3. important
4. somewhat important
5. least important

Problems	Ranking
a) Deforestation	2
b) Urban Waste / Solid Waste Pollution	2
c) Noise Pollution	3
d) Vehicular Pollution	3
e) Industrial Pollution	4

12. What are the sources of drinking water?

i) PHE Supply
ii) Tube Wells
iii) Tankers
iv) Other Sources ......Canals......

13. Do you use any of the following appliances / techniques for water purification purposes?

i) Aquaguard
ii) Zero B
iii) Ordinary Filter
iv) Chlorine / Alum
v) Boil Water
vi) None

14. Please rank the following statement:

"Wetlands like Dal Lake need special conservation measures".

i) Strongly Agree
ii) Agree
iii) Neutral
iv) Disagree
v) Strongly Disagree

15. You may be aware that Dal Lake provide services to a number of villagers around. A few of them are listed below. Kindly rank them according to their importance in your opinion.

1. most important
2. very important
3. important
4. somewhat important
5. least important

Problems	Ranking
a) Drinking Water	1
b) Stability of micro-climate	2
c) Employment to Boatmen, Camel Wala etc	2
d) Recreation and Tourism	1

16. To what extent is the Dal Lake polluted in your opinion?

1. Marginally
2. Moderately
3. Highly
4. Not at all

17. How would you rank the various threats to the Lake in order of importance?

1. most important
2. very important
3. important
4. somewhat important
5. least important

S. No.	Problems	Ranking

A	Siltation	2
B	Solid Waste Pollutants like polythenes etc	2
C	Sewage	1
D	Encroachment	1
E	Increased Population	4
F	Weeds and Eutrophication	2
G	Boating	4
H	Agricultural Waste	2
I	Idol Immersion	5
J	Deforestation	4
K	Ill Planned Development	4
L	Cremation	5
M	Washing and Bathing	1

VALUATION

It is being tried to place a money value on the services that you derive from the Lake. You derive a number of benefits from this lake like recreational opportunities and microclimate stabilization. Suppose, an independent body is formulated by the government for maintaining and developing the lake in the future for recreational activities that would be made available to the people of Jammu and Kashmir. This body would develop and maintain parks around the lake, promote adventure boating and other forms of eco-tourism and other such activities. Besides it would help to maintain the aesthetic beauty of the lake as well. This kind of body would require funds for operating. Suppose that this body would operate only on the funds collected through the voluntary donations/contributions and not through any government aid, we would like to know about your contribution to such a body. The persons contributing to this fund would get a privilege membership in the society whereby they could enjoy the various activities promoted by the society on nominal payment of ticket charges.

18. Assuming that such a body was formed and would work perfectly as specified, how much money would you (and your family) pay voluntarily, every year to enjoy the improved recreational and aesthetic benefits of the Dal Lake.

None – GO TO QUESTION 13

Initial Amount: Rs ....250-500..........

ACCORDING TO THE BAND WITHIN WHICH THIS AMOUNT FALLS, SELECT THE NEXT AMOUNT AND ASK THE FOLLOW UP QUESTION

A. 1 – 250	Ask for Rs 300
B. 251 – 500	Ask for Rs 750
C. 501 – 1000	Ask for Rs 1500
D. 1001 – 2000	Ask for Rs 3000
E. More than 2000	Ask for Rs 5000

4

19. FOLLOW UP QUESTION: Since you are probably doing such a valuation exercise for the first time, let me try and ask you if this is definitely the value you would place on the improved services that you would receive from the Dal Lake.

For Instance, would you pay Rs ……250 – 500/…(value from the list given above corresponding to the band containing the original bid) per years on behalf of yourself and your family, in order to enjoy an improved Dal Lake?

a) Yes

b) No

ENTER THIS AMOUNT AS NEXT VALUE STATED

NEXT VALUE STATED Rs ……250 – 500/-……..

You have a limited income and in that case do you think it will be possible for you to pay the amount that you have stated. **Yes / No**

If you want you can still adjust the amount.

FINAL VALUE STATED Rs ……250 – 500/=……

20. Suppose that the government imposes a compulsory tax upon all its citizens, whereby the collections from this tax would entirely go towards maintaining the lake and providing the activities listed above with no special membership benefits, through the formation of similar body. In this case how much you and your family be willing to pay as tax, every year for obtaining better recreational services from Dal Lake.

a) None - GO TO QUESTION 21

b) Initial Amount Rs ..250 – 500/=…..

ACCORDING TO THE BAND WITHIN WHICH THIS AMOUNT FALLS, SELECT THE NEXT AMOUNT AND ASK THE FOLLOW UP QUESTION

A. 1 – 250	Ask for Rs 300
B. 251 – 500	Ask for Rs 750
C. 501 – 1000	Ask for Rs 1500
D. 1001 – 2000	Ask for Rs 3000
E. More than 2000	Ask for Rs 5000

21. You have a limited income and in that case do you think that it will be possible for you to pay the amount that you have stated. If you want you can still adjust the amount.

FINAL AMOUNT STATED Rs………600……….

22. What is your preferred timing of payment?

a) Monthly

b) Biannually

c) Yearly

23. What expenditures of your monthly household budget will you reduce in order to make this payment?

1. Curtail Personal Expenditures
2. Curtail Domestic Expenditures

24. Should there be a gate fee at the entrance of the Lake?

a) Yes

b) No

IF NO SKIP TO QUESTION NO. 25

If so what should be the amount per adult fixed at?

i) Re 1 – Rs 5

ii) Rs 6 – Rs 10

iii) Rs 10 – Rs 20

5

iv) Rs 21 – Rs 50
v) Above Rs 50

25. People who say no usually have a reason for it. Could you please specify why you are not willing to pay for the benefits of the Lake?

1. The government should pay YES/NO
2. The user should pay YES/NO
3. I cannot afford YES/NO
4. The Lake is not important to me YES/NO
6. Other reasons ……………………………………………………………………

26. Suppose that you were to buy a plot/piece of property here at Dal. What importance would you give to the following factors?

1. most important
2. very important
3. important
4. somewhat important
5. least important

S. No.	Variable	Ranking
1	Proximity to Market Place	2
2	Proximity to the Place of Work	2
3	Proximity to Major Highways	2
4	Proximity to Children's School	1
5	Proximity to Lake	1
6	Proximity to Hospital/Nursing Home	1
7	Quality of Construction	2
8	Age of House	1
9	Housing Density	2
10	General Air Pollution Levels	5
11	Level of Noise Pollution	5
12	Proximity to a Park	5
13	Availability of Household Help	2
14	Availability of Regular Drinking Water	1

27. Do you believe that your answers will influence the decision of the government to create a body for improving the recreational facilities at the Dal Lake?

a) Yes
b) No
c) Perhaps

28. Do you believe that you may be asked to pay for the improvements in the Dal Lake?

a) Yes
b) No

6

c) Perhaps

Thank you very much for your time.

Prasan

Signature of the Enumerator

7

CHAPTER 7

Summary & Conclusions

Conclusions

Freshwater available for direct use in living continuum involves a small volume of total water available on the earth. Freshwater ecosystems, such as rivers, lakes, and ponds, which are rich reservoirs, provide good niches for varied biotic traits, which in turn bestow particular productivity status to natural aquatic ecosystems based on the nature of the dwelling flora and fauna. Despite the fact that freshwater habitats make just a small part of the earth's surface, the ignorance of mankind have reduced them to mere drains for unwanted wastes, arising from human activity. climate change, deforestation, desertification, siltation, unplanned urbanization and industrial development, excessive fertilization of croplands, poor basin management, and other factors are all having a large impact on this small but vital reservoir of life. During the current study all the water quality parameters were found to be on the higher side due to the increased urbanization and unplanned agricultural activity undertaken in the catchment of the Dal Lake. As a result, only reasonable management and conservation strategies can ensure the long-term sustenance of these systems. The values of HMs showed variation between the four sites of the Dal Lake (Table 66). The values of molybdenum in ppb concentrations between the sites was found to be 2.538 ±0.002, 1.703± 0.003,3.627±0.004 and4.787± 0.002 ppb. at the four sites of the Lake respectively, the highest values of molybdenum were reported at the Brarinambal (Site iv) and lowest values at the Habbak site of the water body. (Bahnasawy et al., 2011 and Khan et al., 2012). The chromium being highly toxic was not detected in any of the four sites of the water body during the present study which is a potential cause of many cancers.

Macrophytes constitute the first ladder of aquatic trophic chain, they have been dominating over the period of time which reflects their productivity status and species richness during different seasons. Some of the plants are used as vegetables while others are used as fodder thereby contributing to the livelihood of the people living there, and the GDP of the valley. But, due to increase in population growth and anthropogenic interferences this valued water body has had been under heavy pressure which has resulted in the build up of nutrient contents in this aquatic water body thereby decreasing its species diversity. Consequently, accelerated senescence of the water body presents an eminent threat to the very well being of the Dal Lake. Ecologically sound and robust conservation measures are needed to be prioritized for granting a lease of life to the macrophtic diversity of the lake.

1. A database of macrophyte diversity and water quality parameters need to be created to aid in determining the threat level of the water body.

2. Pollution from point sources can be limited, and de-silting can be accomplished by planting emergent macrophytes at entry sites besides reducing the direct impact of human involvement by providing catchment area protection to the lake.

3. The cultivation of hyperaccumulator plants (*Eichhornia crassipes, Lemna minor*) for heavy metal remediation should be done.

4. Schools, colleges, non-profit organizations, and quality control labs should be encouraged to participate in routine water quality study, which will help policy makers and landscape managers design eco-restoration methods in the future for effective wetland conservation.

5. It is also necessary to levy fines on individuals and organizations that have the potential to disrupt the ecosystem of wetlands.

6. Pretreatment of wastes both municipal waste and sewage before their discharge into the lake.

7. Algal biomass must be removed on a regular basis to maintain the dissolved oxygen levels and to ensure the survival of dwelling species. The macrophytes such as *Azolla* and *Eichhornia* which cause these problems can be composted to produce biogas and biofuel.

8. Development of interagency cross talks involving researchers, academicians, policy makers and landscape managers for effective wetland conservation.

These natural resources are seen as common property resources in economic terms, collectively owned by society as a whole and open access to all. While dealing with how to protect such a resource, conservation biologists all over the world have adopted an econometric technique for the preservation of diversity. The main aim of implementing such an economic methodology in conservation is that government and industry can base their major policy decisions on economic valuation, and if the loss of biological diversity is perceived to be costly. Governments and NGOS may take appropriate measures to prevent it.

Economic valuation addresses the right allocation of environmental products and services in order to increase human wellbeing, thereby improving environmental resource management in such a way that it can be used for eternity. Furthermore, the economic value of a water body is determined by its water quality, so higher the water quality, higher will be the economic value. As a result of these factors, an effort was undertaken to examine the ecological economics of the Dal Lake, which is under significant strain from unregulated tourism-related activities as well as anthropogenic influences such as,

i) To recon the effect of anthropogenic stress on the ecology of Dal Lake.
ii) To find out the important groups of macrophytes growing in the lake
iii) To find out the existing threats to the lake such as:
   a) Incidence of water borne diseases.
   b) Increased deterioration of water quality
   c) To prepare an inventory of economic benefits derived from the lake. The wealth of information so derived has been presented in the present thesis.

Recommendations

1. The development plans should be reframed with the participation of both technocrats and stakeholders (people living around the Dal Lake and the unregulated tourism).

2. Despite the fact that a concrete road has been built around the lake to prevent encroachment, sewage continues to flow into the lake uninterrupted. As a result, an efficient drainage network around the lake is important for sewage to be drained away from the lake.
3. Fertilizers should not be able to enter the lake easily, which cause many problems and should be diverted away from the water body.
4 Use of dustbins should be promoted so that the solid trash generated by tourism can be conveniently disposed off.
5. More floating fountains need to be developed which enhance the oxygen saturation and increase the tourist attraction.
6. Converting wastelands around the lake into green belt areas would provide tourists more choices of recreation around the lake.
7. Construction works in the immediate vicinity of the Dal Lake should be properly monitored so that there is a minimum footfall on the lake ecosystem.
8. Extraction of water by the Jal Shakti Department for the drinking purposes should be scientifically regulated so that the ecological balance is maintained.
9. To protect the lake banks from the erosive effects of moving water, emergent macrophytic plant species should be planted.
10. More sewage treatment plants should be established on the lake banks for the effective treatment of polluted waters which otherwise cause eutrophication problems.
11. All inappropriate activities in and around the lake should be prohibited especially fecal contamination by the houseboat owners.
12. An elaborate and in-depth study need to be undertaken on the ecology and conservation biology of Dal Lake by utilizing modern technology.
13. With the recent declaration of part of Srinagar City as the heritage site by UNESCO, steps need to be undertaken to declare Dal Lake as the internationally acclaimed site (Ramsar site) so that the management plans can be taken to the logical end.

14. Awareness programs and effective legislation should be enforced so that the common people can get information about the importance of this lake for the very benefit of the whole community.
15. Two-to-five-kilometer area around the Dal Lake should be declared as the catchment area so as to minimize the human interference on the lake.
16. Strict enforcement of laws to put tax on the services derived from the Dal Lake and the imposition of fine to the local as well as non local visitors who violate the ecological condition of the lake, however stricter fine should be imposed to the local people who are frequent visitors and pollute the water body.

CHAPTER 7

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Appendices

Research article(s):

- Parray, S.Y., koul, B., 2020. Impact of agricultural activity and human settlement on the limnology of chatlam wetland pampore, India. Journal of Critical Reviews, *7*(18), 801-809.

- Parray, S. Y., Koul, B., Shah, M. P., 2021. Comparative assessment of dominant macrophytes and limnological parameters of Dal Lake and Chatlam wetlands in the Union territory of Jammu and Kashmir, India. Environmental Technology and Innovation, 24, 101978.

- Parray, S.Y., Singh S., Koul B., Khan N. A., Ramamurthy P.C., and Singh J., 2024. Economic Valuation and Characterization of Heavy Metal Contamination in Dal Lake Srinagar, Kashmir, India. Heliyon, 10(14), E34108

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IMPACT OF AGRICULTURAL ACTIVITY AND HUMAN SETTLEMENT ON THE LIMNOLOGY OF CHATLAM WETLAND PAMPORE, INDIA

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Abstract
Human settlement and the impact of unsustainable agricultural activity in the catchment of Chatlam a suburban wetland has been evaluated together with its impact on the limnology of the ecosystem. Detailed survey was conducted to find out the population and cattle head count.. During the study 12 villages consisting of about 4000 families in the vicinity with human population of about 35000 and cattle head count of 12400,directly or indirectly effect the wetland ecology. Study of land use pattern indicate 1360 ha under various agri zones which involve annual use of 265 metric tons of fertilizers and 1.75 metric tons of pesticides. Due to unplanned development the physicochemical properties of water showed fluctuations from the normal pattern. The physicochemical parameters like pH· conductivity, chloride, nitrate nitrogen, nitrite nitrogen and orthophosphate were assessed and showed gradual increase during the study period. Macrophytes constitute an important part of water bodies and their frequency or abundance increases or decreases with the productive status of the wetlands. During the present study 23 species of macrophytes were recorded and extinction of world famous *Nelumbo nucifera*. The unplanned agricultural practices together with rapid urbanization has reduced the area of water body from 44 to 39 ha thereby endangering the aquatic and avifaunal diversity. The present study will try to find out the possible cause of anthropogenic stress and the possible measure to conserve it. At the end recommendations have been suggested to mitigate some of these issues in order to contribute to sustainable wetland management.
Key Words: Human settlement, Chatlam wetland, Conservation.

1. Introduction

Kashmir Himalayas play a very important role in the socioeconomic development of the state .Global wetlands which occupy about 9 percent of the land surface but contain about 35 percent of the total carbon pool which in turn contributes to their productivity (Wani et al., 2018). Wetlands provide series of benefits such as biodiversity, filtering of water, ground water recharge, mitigating climate change and stabilization of microclimate (Shah et al., 2015). They also help in the pollution control by acting as sponges of plant nutrients. Anthropogenic activities pose serious ecological and environmental problems like algal blooms, red tides and oxygen starvation which leads to fish mortality and avifaunal deaths (Khan et al., 2004). Local population exploit the water body for different purposes (Falah and Haghizadeh 2017). Due to urbanization and unsustainable agricultural practices wetland ecosystems are under serious threat of extinction (Bhateria and Jain 2016).The water bodies throughout the globe are under anthropogenic pressure due to unplanned growth .Chatlam wetland which is surrounded by the world-famous saffron fields (1360 hectares under various agri zones mainly saffron fields) receive industrial and agricultural surface runoff, 265 metric tons of fertilizers and 1.75 metric tons of pesticides leading to eutrophication and extinction of important biotypes(Parray et al., 2009; Shah et al. 2019).A wealth of literature is available on the limnology of Kashmir wetlands. Mukherjee (1921, 1926, 1932) studied ecology, succession with special reference to light penetration in Dal Lake, Kashmir. Meybeck (1982) found that eutrophication of wetlands enhances the planktonic primary production. Zutshi (1971)

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Comparative assessment of dominant macrophytes and limnological parameters of Dal lake and Chatlam wetlands in the Union territory of Jammu & Kashmir, India

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ABSTRACT

The aim of the study was to analyze and compare the physico-chemical properties of water, with respect to the anthropogenic stresses on the growth and dominance of aquatic macrophytes at the four selected sites in Dal lake and Chatlam wetlands, during the year 2020. We have identified 12 species of macrophytes from the Dal lake and 20 species from the Chatlam wetlands. Highest importance value index (IVI) was observed in *Nymphoides peltata* (48.98) during summer and the lowest IVI was in *Mentha* sp. (1.93) during winter in the Chatlam wetlands. On the contrary, in Dal lake the highest IVI values were reported for *Azolla* sp. (175.34) during summer and lowest for *Hydrocharis dubia* (10.60) during winters. The average values of Biological oxygen demand (BOD), Chemical oxygen demand (COD), nitrate nitrogen, ammoniacal nitrogen and orthophosphate content in Chatlam were 19.85 $\pm$ 0.91(mg/l), 62.5 $\pm$ 1.29 (mg/l), 516.25 $\pm$ 1.10 (μg/l), 291.75 $\pm$ 1.55 (μg/l) and 136.75 $\pm$ 0.47 (μg/l) respectively. While in Dal lake, the observed values of these parameters were 27.5 $\pm$ 1.49 (mg/l), 61.75 $\pm$ 0.85 (mg/l), 636.5 $\pm$ 1.04 (μg/l), 137 $\pm$ 1.31(μg/l), and 44.6 $\pm$ 0.18 (μg/l), respectively. We found that the Chatlam wetland (sub-urban area) harbored more macrophytic diversity than the Dal lake (urban). Unplanned development and agricultural activities in the catchment area have significantly contributed to the cultural eutrophication. In lieu of these findings we propose that joint efforts of the researchers, government and the non-governmental organizations be put in for the sustainable conservation of these two wetlands.

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Research article

Economic valuation and characterization of heavy metal contamination in Dal Lake Srinagar, Kashmir, India

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ABSTRACT

Dal Lake, the world-famous tourist attraction has been polluted by allochthonous and autochthonous sources, as a result the heavy metal (HMs) concentrations within the water body has reached the toxic levels which is endangering the lives of the people. A study was carried out during the year 2021 (i) to determine the concentration of HMs (molybdenum: Mo, arsenic: Ar, cadmium: Cd, lead: Pb) at the four designated sites of Dal Lake, and (ii) a public survey (400 persons) involving economic valuation of water body in terms of recreational use and other benefits. The highest values of biological oxygen demand (BOD) and chemical oxygen demand (COD) within the Dal Lake were recorded at site A, which were 31 ± 1.10 mg/l and 76 ± 0.64, respectively. Similarly, maximum nitrate nitrogen was found at site A (865 ± 0.86 μg/l). The highest value of Pb was reported (6.828 ± 0.003 ppb) from site A whereas, the lowest from site B (2.492 ± 0.002 ppb). The mean values of Mo concentrations (in ppb) were found to be 2.538 ± 0.002, 1.703 ± 0.003, 3.627 ± 0.004 and 4.787 ± 0.002 at the four sites respectively. The observed values of HMs (in ppb) were much higher than the permissible values (WHO, 2006) and those reported earlier. A huge amount of money (Rs 16,18,66,000/) is being generated from the floating gardens of Dal Lake, calculated by TCM and CVM methods. During the survey, 68 % of people showed a willingness to pay (WTP) for the restoration of the Dal Lake and improved services (mean value: Rs 62,852.20/). Thus, the monitoring and assessment were done to find out how the Dal Lake contributes to the economy of the state by way of its different services and the major attraction for tourists besides the possible reasons for the deterioration of water quality, in order to find a long-lasting solution for the sustainable conservation of Dal Lake.

1. Introduction

The Kashmir valley is bestowed with a plenty of wetlands which provide a diverse set of products and services for human

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CHAPTER

9

Biochemical and molecular aspects of heavy metal stress tolerance in plants

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9.1 Introduction

Heavy metal (HM), popularly known as high atomic weight elements, resembles metallic objects at room temperature in properties and general characteristics. HMs are known to be elements with specified gravity above 4.0 between Vanadium and Bismuth. HMs are very toxic in higher doses, although they are needed in small quantities. The HM accumulation is increasing due to human interference and thus poses a major menace to agriculture and human health (Koul and Taak, 2018). Municipal waste disposal and uncontrolled mining are contributing more to the accumulation of HMs in the environment.

The toxicity of HMs causes tissues to suffer oxidative damage, including (1) fat peroxidation of membranes, (2) DNA damage, (3) the oxidation of protein sulfhydryl groups. However, in their response to HMS, plant species vary, some species are easily susceptible, while others show higher tolerance levels to higher HM concentrations. Plants are categorized into two classes based on their ability to interact with the HMS (1) avoidance of HM and (2) HM tolerant plants. The first category of plants restricts HMS entry into the plant by the root cell membrane permeability barrier. The second category of plants direct the metals to the vacuole after absorption without causing any harm to the plants.

Proteins are macromolecules that are functionally flexible and form the main agents of living cells. They work in cell signaling processes, control catalytic reactions, nutrient and other molecules, inter- and intra-cellular movement & defence (Amm et al., 2014). Amino acid construction of a protein determines its function, which is formed by amino acid ribosomal synthesis. In addition, protein conformation depends mainly on the physicochemical protein environment, which is influenced

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