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A COMPREHENSIVE STUDY ON ASSESSMENT OF WATER QUALITY PARAMETERS AND POLLUTION SOURCES IN DAL LAKE, SRINAGAR

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ABSTRACT:

Water is the most vital and one of the most basic needs of existence. No one can survive without water. Freshwater bodies, especially lakes, are susceptible to a variety of natural processes that occur in the environment, including the hydrological cycle. Surface water runoff and sewage discharge into lakes are two frequent methods for nutrients to infiltrate aquatic ecosystems, resulting in their mortality. The Kashmir valley is well-known for its abundant freshwater resources, which include lakes, glaciers, rivers, ponds, and springs. Situated in Kashmir toward the upper east of Srinagar, the Dal Lake was previously a well known vacationer location. Moderately talking, the Dal Lake, the gem in Srinagar's crown, is continually battling pollution. Fix and upkeep of the water system rely upon both the appraisal of its water quality pointers and the area of the wellsprings of defilement. This study's essential objective is to look at the Dal Lake, Srinagar, water quality boundaries and pollution sources appraisal. The exhaustive audit of Dal Lake, its water characteristics, water quality boundaries, changes in water quality boundaries, the impact of water quality on lake environment, pollution and its sources, the board of pollution in Dal Lake, etc. were undeniably shrouded in this audit article.

Keywords: Water quality, pollution, Dal Lake, resource, Jammu and Kashmir etc.

INTRODUCTION:

The elixir of life is made up of water. It plays a significant role in guaranteeing the survival of humans. As a result of fast growth and a rise in population, there has been a significant increase in the need for water that is both clean and portable. The need for water in all forms of life, from microorganisms to humans, is a significant issue in the modern world. This is owing to the fact that all water supplies have reached a point of crisis as a result of unplanned urbanisation and industrialization [1]. Not only is there a desire for human people, but there is also a want for aquatic life, which is defined as life that lives in water and ultimately becomes a source of protein for humans. Therefore, it is of the utmost importance that every effort be made to safeguard and preserve the water resources that are already available in order to meet the requirements of both the present and the future. In the environment, lakes are susceptible to a variety of natural processes, such as the hydrological cycle, which are all occurring simultaneously. The discharge of sewage into lakes and the runoff of storm water are two frequent ways that different nutrients enter aquatic environments, which

ultimately leads to the demise of such ecosystems.

The availability of fresh water is a limited resource on earth, yet it is necessary for human survival, as well as for agriculture and industry. It will not be feasible to achieve sustainable development if there is not sufficient quantity and quality of fresh water accessible. [2] The degradation of freshwater resources is occurring rapidly and progressively. Currently, water quality has become a worldwide issue. [3] The health of an aquatic environment relies on both its biological variety and its physico-chemical features [4]. Streams, lakes, rivers, seas, and oceans make up the majority of the water that covers the earth's surface, which accounts for over 71% of the total surface area. Water is the most significant geological agent that has a significant impact on the surface shape of the planet on a very large scale. [5].

Regarding the state of the environment, there has been a significant decline in the quality of the environment. In addition to the fact that natural pollution influences the air we inhale, yet it likewise affects the water we drink and the land we stroll on. Considering that there is a restricted amount of water and that demand is supposed to rise, we should focus harder on it.. After pollution in the air, the most significant danger that the whole globe must contend with is contamination in the water [6]. The primary sources of pollution in our water bodies are domestic trash, industrial effluents, agricultural waste, and other similar contaminants. The contamination of groundwater occurs due to the infiltration of various pollutants such as soakage pits, septic tanks, manure, rubbish, and other sources [7]. Most issues get from deficient sterile offices and an insufficient waste administration system. [8] Big hauler stacks and dumps along the coast bring about oil slicks, which are perilous since they harm oceanic life notwithstanding the water. These spills are a threat because they affect wildlife as well [9]. Pesticides and other chemicals are found in agricultural waste, which contributes to the contamination of water by filling it with nitrates and phosphates. They are also found in agricultural trash. The presence of these contaminants unquestionably results in an ecological imbalance in the bodies of water. [10]

Water bodies lose their ability to recycle waste and become less capable of self-purification due to all types of pollution. Water bodies get shallower and the quality of the water is impacted as a consequence. [11] Contaminants may include both organic and inorganic contaminants. Organic water contaminants include substances such as detergents and disinfection byproducts, including chloroform, which are present in chemically treated drinking water. Food processing waste may include various components such as oxygen-demanding compounds, lipids, grease, pesticides, herbicides, a wide variety of organohalides, and other chemical compounds. Petroleum hydrocarbons, such as gasoline, diesel, lubricants, and the byproducts of fuel combustion, are present in storm water runoff.

The objects resulting from logging activities, as well as volatile organic chemicals like industrial solvents, which have been stored improperly. Chlorinated solvents have the potential to settle to the bottom of reservoirs. Personal hygiene and cosmetic goods include

polychlorinated biphenyl, trichloroethylene, perchlorate, and different chemical substances. Examples of inorganic water contaminants are sulphur dioxide emitted by power plants and ammonia released from food processing waste. Compound waste from modern cycles, composts with nitrates and phosphates found in stormwater spillover from private, business, and horticultural regions, weighty metal outflows from engine vehicles, corrosive mine seepage, residue conveyed by overflow from building destinations, logging activities, slice and consume practices, and land clearing locales are a portion of the wellsprings of pollution. [12, 13]

Visible objects, such as litter and waste, that is dumped by individuals on the ground and carried by rainwater down storm drains, ultimately ending up in surface waterways. Power stations and industrial enterprises often contribute to thermal pollution by using water as a coolant. Increased water temperatures lead to reduced oxygen levels, resulting in fish mortality and altering the character of the ecosystem, including the introduction of new thermophilic species. Urban runoff may also increase the temperature of surface waterways. [14] Rivers transport the majority of water contaminants to the seas. Numerous substances go through synthetic changes or responsive debasement, particularly when left in groundwater supplies for significant stretches of time. Chlorinated hydrocarbons, which are utilized in the laundry business and incorporate trichloroethylene and tetrachloroethylene, comprise a huge subset of these synthetics. Because of inadequate breakdown processes, both of these mixtures — which can possibly cause malignant growth — structure other dangerous synthetic compounds such dichloroethylene and vinyl chloride.

Jammu and Kashmir is a lovely region on the planet with a wealth of water resources. There are many waterways in Jammu and Kashmir; Dal Lake is the second biggest after Wular Lake. At a height of around 5000 feet above ocean level, Dal Lake is arranged near Srinagar, the capital of J and K. One notable oceanic landmark on the planet that must be safeguarded is the Dal Lake. To save the perfect excellence of the water body, the Jammu and Kashmir Lakes and Waterways Advancement Foundation was laid out by the state administration of Jammu and Kashmir [15]. In order to prevent the extinction of this globally renowned water body, it is imperative for both governments and the public to be cognizant of the significance of conserving it, as well as maintaining its water quality.

DAL LAKE:

Dal Lake, the second-biggest lake in the territory of Jammu and Kashmir, is the most well known lake there. The lake used to be viewed as quite possibly of the most wonderful lake on the planet. Yet, considering that the lake has endured enormously as far as the two its ecosystem and hydrology, the assertion isn't practical in the advanced period [16].

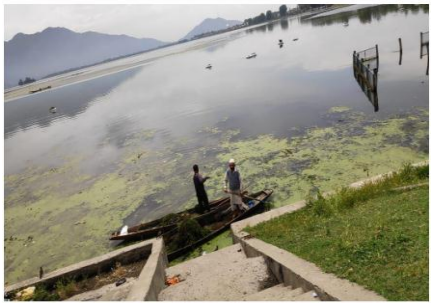

Figure 1: Dal lake

Dal Lake is a metropolitan lake in the Kashmir Himalayas situated in the province of Jammu and Kashmir, explicitly in the city of Srinagar. At a typical level of 1583 meters above mean ocean level, it lies somewhere in the range of 34°5′ and 34°9′ North and 74°49′ and 74°53′ East arranges. Dal Lake is an essential component of Kashmir's tourist and leisure industry, and it also provides economic advantages in the form of fishing, the harvesting of water plants, and the cultivation of vegetables in floating gardens. The human interference that occurred as a result of the settlement in the lake to ease pedestrian traffic and the formation of lake tourism by offering floating houses (houseboats) became more rapid. The length of the lake is 7.44 kilometres, which is equivalent to 4.62 miles, and its breadth is 3.5 kilometres, which works out to 2.2 miles. The lake has an average elevation of 1,583 metres, which is equivalent to 5,190 feet. The depth of the water ranges from a maximum of 6 metres (20 feet) in Nagin Lake to a minimum of 2.5 metres (8.2 feet) in Gagribal Lake, which is the shallowest of the lakes [17]. The position of Dal Lake and the catchment region that it encompasses is shown in Figure 1. This information was obtained from the digital elevation model (DEM) of the basin by using the ArcGIS programme. Both the north and northeast sides of the lake catchment are dominated by mountain ranges, while the other sides of the lake catchment are surrounded by fertile agricultural land. The catchment area is distinguished by its harsh mountainous landscape and its high relief. It is a multi-drainage basin that has a total area of 24 km2, while the catchment area extends over 337 km2 [18]. The lake's water storage capacity is 15.45 million cubic metres (Mm3), and its open water area is around 10.5 square kilometres (km2). Dal Lake has historically served as the birthplace of civilization in the Kashmir valley and is often regarded as the central and vital feature of Srinagar [19]. It is now regarded as one of India's most exquisite National Heritage Sites. It is essential to the economy of the area since it provides a living for a large number of Srinagar city residents. In addition to being one of the most popular tourist sites, the lake provides the community with leisure opportunities, veggies, and fish. Another significant component of Srinagar's water supply comes from the lake waters.

Situated in the foothill formations of the Zabarwan mountain valley watershed, the lake is surrounded on three sides by the Himalayan range, which is a subsidiary of the range. It is an essential part of Srinagar and is located to the east and north of the city. Its catchment gets 655 millimetres (25.8 inches) of rainfall on average year, which falls both in the summer and winter. The lake's summertime temperatures vary from 12 to 30 °C (54 to 86 °F), while wintertime temperatures range from 11 to 1 °C (52 to 34 °F) [20]. The lake undergoes freezing as temperatures plummet to around -11 °C (12.2 °F) during harsh winter conditions. In light of its warm way of behaving, the lake has been arranged as warm monomictic under the sub-tropical lake classification. In spite of the fact that spring sources are viewed as adding to the stream, their exact effect not entirely settled because of an absence of accessible information. Moreover, 80,000 tons of sediment are supposed to be added every year, of

which 70% comes from the Telbal Nallah. It is assessed that 36,300 tons of material will collect in the lake. [21].

WATER QUALITIES OF DAL LAKE:

A variety of factors have contributed to the fact that the management of lakes is becoming more concerned with the quality of the water. The water quality index is strongly connected to the use of water, which encompasses activities such as water supply, conservation of fish and animals, recreation, sanitation, and other activities. Water, which is regarded to be one of the most significant and precious natural resources on Earth, is something that is shared by all of the living species that are now present on the planet that is considered to be "Earth." There are a variety of natural water resources in India, which are dispersed in an uneven manner throughout the nation. However, the existence of these resources in the Himalayan area is of considerable significance since these resources are the primary supply of freshwater for the local inhabitants, tourists, trekkers, sages, and animals. [22]

The water quality and groundwater level are directly and indirectly impacted by the state of a surface water body. Lakes are inland bodies of water that are very significant to civilization because they provide drinking water and water for a variety of human uses. A surface water body's water quality is influenced by both natural and manmade factors, including urbanisation, industry, and agricultural activities, in addition to natural factors like precipitation inputs and soil erosion [23]. Alterations in the species composition and a decline in the general health of water bodies have been brought about as a consequence of the deterioration of water quality brought about by a variety of human influences. The mountainous area is where the majority of natural lakes may be located.

The most important factor in determining whether or not human life will continue to exist is water. It is not only water that has the highest recreational value from an economic point of view; water bodies, such as lakes and rivers, also have this value. When it comes to the preservation of ecological balance, these bodies of water are very important since they serve as habitats for the aquatic flora and animals. Every unjustifiable event, such as unplanned urbanisation, industrialization, and unlawful intrusion of these water bodies, has a severe impact on the ecology and sustainability of these bodies of water [24]. The previously mentioned parts have the inborn ability to adversely influence the water's quality, maybe making it unsuitable for human and marine utilization. The volume of a lake is fundamentally impacted by how much precipitation, surface spillover, groundwater stream, capture, and deliberation that happens during the year. These elements then affect the amount of poisons that are available in a waterway.

The impacts of climbing temperatures, changed hydrological systems, high nitrogen loads, and the presentation of non-local species into amphibian conditions have proactively been shown in Dal Lake. The lake's water quality has totally corrupted because of untreated sewage being delivered into it from various point and non-point sources [25]. Changes in land use and land cover

designs around the lake, touching practices, rural activities, and woodland cutting make all exacerbated the difference. [18]. The aforementioned activities have resulted in an elevation in sediment and nutrient concentration in the lake waters, leading to a decline in the overall quality of the water. Furthermore, the extensive intrusion and release of human waste from houseboats have resulted in a significant proliferation of weeds in the lake [26]; [27]. In particular, the fast and unrestrained development of weeds, namely Azolla pinnata, has had a significant negative impact on the water quality and aesthetic value of the lake [28]; [29]. Despite the fact that a significant number of inhabitants make their living from the lake via activities such as agriculture, tourism, fishing, and other activities, these activities have become a threat to the lake [30].

As a result of decreased hydrological inputs into the lake, the concentration of a variety of contaminants in the water of the lake continues to become increased [31]. Numerous locations utilise the water that was formerly directed towards the lake for drinking and agriculture. Another significant factor contributing to deterioration is the spread of floating gardens, which turn submerged ground into dry land. The local community has replaced the lake with residential developments in many spots. Additionally, a major decrease in the cryosphere in the Kashmir Himalayas as a result of climate change has decreased streamflow, which constitute a crucial component of lake water inflows [32]; [33]. Multiple investigations have been carried out periodically to evaluate the water quality of Dal Lake. Nevertheless, the lack of extensive and uninterrupted historical data has prevented the examination of the lake's water quality fluctuations. Over the last thirty years, the lake's water quality has seen a significant transformation. The lake waters have undergone a drastic metamorphosis, transitioning from being renowned for their pristine clarity to being considered unsafe for drinking and household use.

The quality of whole aquatic habitats is impacted by the combination of population increase and its extensive human activities, which in turn affect the hydrochemistry of hydrological ecosystems. Therefore, the surveillance of water quality is an essential need for effective water resource management. An investigation of lake water samples from various lakes worldwide has shown a rapid increase in eutrophication. This is mostly caused by the direct or indirect introduction of human-generated garbage into water bodies, particularly lakes located in heavily urbanised regions [34]. Therefore, analysing physio-chemical characteristics is crucial for identifying the contamination level of a lake.

Besides, the quality of surface water is enormously influenced by human exercises such air pollution, sewage release, the utilization of farming pesticides, harmed soils, and thoughtless land use. Throughout recent years, Dal Lake's water quality has radically declined because of immediate and aberrant natural changes welcomed on by human action [35]. Taking into account current realities over, the Kashmir valley in India is notable for its shocking landscape, which incorporates streams, high-height grasslands, snow-covered mountains, and lakes with perfectly clear water. There are a few spots in both

rustic and metropolitan neighborhoods where one can track down the shocking perspective on the Kashmir valley. One of the main metropolitan lakes in Jammu and Kashmir is Dal Lake, which is vigorously remembered for the state's travel industry picture. Settled under rich green glades and the shadow of the Zabarwan Slopes, Dal Lake offers a variety of pleasant vistas. In any case, various variables that are exceptional to Dal Lake itself have vexed the organic balance of the lake. Encroachment, pollution, and degradation are some of the new concerns that are making their appearance. The extension of Srinagar city towards Dal Lake, which was forced by humans in the 18th and 19th centuries, has had a significant impact on the water quality of the lake and the areas around it [36]. For this reason, monitoring and planned modifications are very necessary in order to manage these aquatic resources in a sustainable manner.

WATER QUALITY PARAMETERS OF DAL LAKE:

Temperature:

Temperature is an important factor in affecting the performance of other water parameters [37]. The temperature fluctuated between 6 and 8 degrees Celsius during the winter and between 15 and 24 degrees Celsius during the fall season. In Kashmir, the temperature experiences a decline in winter, a rise in summer, and remains mild throughout fall.

Transparency:

The amount of light that is able to penetrate an aquatic system has a substantial influence on the biological activities that take place inside that system, and as a result, the productivity of that system. According to the findings of one of the oldest published investigations, the transparency values of Dal Lake change throughout the year throughout various seasons. During the spring and summer months, there is a limited amount of transparency, however during the winter months, there is a large rise. Additional studies have determined that the fluctuations in the lake's transparency may be attributable to a number of different causes, including the presence of plankton populations and extraneous debris. Equivalent encounters with occasional variances in straightforwardness were likewise seen by these specialists. The mean profundity of perceivability in the lake had dropped from 1.96 meters in 1987 to 1.49 meters in 2005 [38]. The worth diminished considerably more to 1.46 meters in 2013 [31] and 1.32 meters in 2020 [40]. The lake's straightforwardness has diminished emphatically. How much waste and untreated sewage that have entered the lake has made it harder to see where it counts. The unreasonable development of oceanic vegetation in the lake and eutrophication have demolished the impacts [41]. The residue load in the lake has likewise been impacted by changes to the land cover and land use inside the lake watershed.

pH:

Hydrogen ion concentration, often known as pH, is a measurement that indicates the amount of hydrogen ions present in water. This value is used to establish whether or not water is suitable for a variety of applications [42], [43]). During the winter season, the pH varied from 7.4 to 7.9, whereas during the fall season, it was between 8.6 and 9.4 on the

pH scale. The fall season was when it was at its highest. pH plays a significant role in the regulation of metabolism and the maintenance of the body's equilibrium.

Dal Lake was an alkaline lake from the start. Average pH values in the lake throughout the year vary from 7.4 to 8.9. [44]; [45]). pH values have been trending towards fluctuations since 1987. [46] determined that the pH of the lake had an average of 8.4 and varied from 7.4 to 9.5 at various times. The average value in 1990 was estimated to be 8.7 [47]. Between the years 1997 and 2010, pH readings dropped to 8.2, however in 2017, they were reported to be higher, coming in at 8.4 instead. When it comes to deciding whether or not the waters of the lake are acceptable for various uses, pH is an essential element to consider. The pH of the lake in the past has been alkaline, and it continues to be alkaline now. The fact that its value is subject to significant shifts, on the other hand, is an indication that the well-buffering aquatic system may undergo a slow transformation [48]. One possible explanation for this is because the lake has significant amounts of pollution loads, which continue to rise over time.

Conductivity:

The conductivity of a body of water is directly connected to the trophic state of the water body, with a low oligotrophic status (meaning the water body is lacking in nourishment) and a high eutrophic status. Different basins of Dal Lake had fluctuations in conductivity levels over the period of 1998–1999, ranging from 122 to 759 µS. Earlier on, Kaul (1977) [49] reported conductivity readings in the basins ranging from 95 to 240 µS, but Trisal (1987) found readings between 270 and 490 µS. The conductivity levels of the lake range from 300 to 642 µS, according to recent investigations [50]; [51]). A key measure of contamination for shallow lakes, such as Dal Lake, is conductivity [52] and evaluate the aquatic systems' trophic state [53]. There is a significant amount of sediment, sewage, and fertilisers in the lake's information streams, which may be related to the rising conductivity values of the lake's waters. Additionally, the steady rise in conductivity values of lake waters has been caused by the presence of agricultural fields and human habitations in the vicinity of the lake, as well as changes in the land use and land cover of the lake catchment [54].

Turbidity:

Turbidity is the most important aspect in determining the relative clarity of the liquid, as well as the optical property of the water and the measurement of the quantity of light that is dispersed by the substance that is present in the water molecule. During the winter season, the turbidity values varied from 4 to 16 NTU, whereas during the fall season, they were between 11 and 28 NTU. [55]

Carbonates and Bicarbonates:

The mix of carbonates and bicarbonates, which are likewise used to recognize delicate and hard water bodies, decides the general alkalinity of an amphibian system. Hard water is defined as water having alkalinity levels that are more than 90 mg/l. The water from Dal Lake was determined to be of a hard kind by [46]. The lake had alkalinity levels that ranged from 70 to 134 mg/l during the course of that time period. There was a significant increase in the hardness of water over the course of the preceding decade, as shown by the fact that the

alkalinity ranged from 37 to 249 mg/l over the years 1998–1999. With respect to the most recent information that anyone could hope to find on Dal Lake, the alkalinity level remaining parts north of 90 mg/l for most of the year. The lake is consequently named having hard water [30]. Despite the fact that bicarbonates were tracked down throughout the entire year, carbonates were just found throughout the late spring season, when the pH was fairly high. In the base water, just bicarbonates were found [56].

Dissolved Oxygen:

Aside from its basic job in controlling the metabolic exercises of amphibian life forms, oxygen likewise works as a mark of the general prosperity of lakes. The dispersion of oxygen in profound still up in the air by separation, or its shortfall [57]. The oxygen levels in Dal Lake are almost completely stable from the top to the bottom, despite the fact that it is a body of water that is quite shallow [31]. It has been discovered that the heat cycle of the lake and the dissolved oxygen (DO) of the lake are strongly connected to one another. During the winter, DO levels are high, whereas during the summer, they are low. During the year 1987, the mean annual DO The scope of values at a few lake areas was somewhere in the range of 0.8 and 12.05 mg/l. DO levels just momentarily increment because of the deweeding methodology [58]; [47]. Dissolved oxygen (DO) levels in the lake have diminished throughout recent years, from 7.4 mg/l in 1997 to 6.9 mg/l in 2017. Dal Lake's dissolved oxygen content has been fundamentally declining since the 1990s. The essential driver of this reduction is the expanded nitrogen levels in the lake, which have energized the development of the two weeds and macrophytes. The oxygen need of macrophytes and their disintegration, along with the breath of microbes and oceanic life, are the primary drivers of the quick consumption of free oxygen. A reduction in how much dissolved oxygen in lakes is one of the most serious outcomes of tainting. The quantity of gaseous oxygen that is dissolved in water is sometimes referred to as dissolved oxygen (DO). In the winter, the DO levels varied from 7.2 to 9.5 mg/l, whereas in the fall, they were between 5.4 and 7.8 mg/l. As a result of temperature, the levels of dissolved oxygen are generally greater during the winter months and lower during the other seasons [59], [60], and [61] presented explanations that were comparable to those given for increasing and decreased DO over the various seasons.

BOD:

The biological oxygen demand, frequently known as Body, is the amount of oxygen that is utilized by microbes and different microorganisms during the method involved with deteriorating natural waste under high-impact conditions and at a specific temperature. The biological oxygen demand (BOD) varied from 20 to 60 mg/l during the winter season and from 33 to 60 mg/l during the fall season. [62]

Cationic Elements:

Within the Dal waters, the divalent cationic elements that are found in the greatest abundance are calcium and magnesium. Ca, magnesium, sodium, and potassium are the typical ordering of cations in lake water. Dal Lake is classified as a calcium-rich lake by Ohle, according to the classification system [63]. The lake has been shown to exhibit

seasonal variations in the concentration of cationic elements. When summer arrives, the levels of calcium and magnesium in the body are at their highest [64]. There is a significant amount of variation in the levels of sodium and potassium discovered in the lake. Potassium content is at its maximum during the early spring and at its lowest throughout the summer, in contrast to sodium, which does not exhibit any discernible pattern. The maximum concentration of calcium ions in the lake water has not surpassed 100 mg/l in recent times, while the concentration of magnesium ions has remained below 30 mg/l during this time period. The values, on the other hand, are very low as compared to the observations made in the past. Ishaq and Kaul (1988a) [65] found quantities of magnesium ions as high as 92 mg/l and calcium ions as high as 432 mg/l. The concentration of all cationic elements in the lake has increased significantly during the last 30 years. The leaching of these minerals from agricultural soils is the reason Dal Lake has such a high percentage of magnesium and calcium. One possible explanation for the rise in the lake's cation content is the increased usage of chemical fertilisers in the surrounding agricultural regions. The increasing leaching of these ions into the lake water is caused by farming activities in the lake watershed. Composting macrophytes is another potential source of elevated Mg2+ levels [63].

Hardness:

During the winter season, the values of hardness varied from 173.0-241 mg/l, whereas during the fall season, the values ranged from 132-236 mg/l. Hardness is defined as the quantity of calcium and magnesium that is dissolved in water. [66]

Nitrates:

During the 1970s and 1980s, researchers took a gander at [67] In most Dal Lake bowls, inorganic nitrogen was found in follow levels or less. High centralizations of ammoniacal nitrogen (NH3-N) and nitrate-nitrogen (NO3-N) were just found in the Brarinambal area. The principal wellspring of nitrogen in the lake climate was viewed as nitrate-nitrogen, which had values going from 80 to 650 µg/1. Follow levels of different types of nitrogen were found. Then again, records from 1998 to 1999 demonstrate a huge expansion in inorganic nitrogen in the lake, showing critical pollution. The expansion in natural squanders in Dal Lake, which in the end deteriorate, is the reason for the ascent in the lake's nitrate focus. Ammoniacal nitrogen delivered into the water is advanced in lakes by expanded natural material breakdown [68]. The flood of ammoniacal nitrogen from the base to the surface might be brought about by human action, including digging and de-weeding activities. This is an extra justification for the increment. Two other conceivable reasons for this peculiarities are the immediate surge of crude sewage from inside and around the lake, and the fast flood of manure. The expansion of nitrate levels in the lake may be credited to the draining and surface spillover of nitro-phosphate manures from a close by cultivated district, notwithstanding the arrival of home sewer from residences and houseboats into the lake.[69].

Total Dissolved Solids - TDS :

The entire concentration of dissolved solids in the water is that which is referred to as the total dissolved solids.

During the winter, the TDS levels varied from 65.1-95.1 mg/l, whereas during the fall, they were between 64.3-90.0 mg/l. In the winter, there is an increase in the number of organic materials, which causes the turbidity to rise. [70] and [71] have furthermore seen a rise in turbidity in a number of aquatic bodies that receive sewage and waste water.

Total Phosphorous:

There has been a discernible upward trend in the overall phosphorus content that is existing in the lake. In earlier studies, it was shown that the lake had low amounts of complete phosphorus as well as phosphorous stacking [72]. The silt, especially the top layer, are where the best measure of complete phosphorus is found. The sedimentation of this mineral after precipitation is thought to be the reason for this peculiarity. The complete phosphorus content has developed from 0.1 to 0.4 mg/l in 1997 to around 6 mg/l in 2017. This represents a significant increase. A number of other studies have also presented findings that are comparable to these. It is generally agreed that phosphorus is the most important limiting nutrient, which is responsible for the eutrophication of freshwater systems [73]. Despite the fact that algae only need a little amount of it, it is an essential nutrient that is responsible for eutrophication [74]. One of the possible causes might be the increasing levels of eutrophication that are occurring in the Dal Lake system. Extreme drainage from floating gardens and agricultural catchments via Telbal and Botkol streams is the source of the significant increase in total phosphorus. This is also the reason for the considerable increase's presence. The rapid eutrophication may also be attributed to the presence of phosphate in the lake water, which is acquired via the use of home wastewater.

Total Alkalinity:

The ability of a body of water to act as a buffer against acidity is referred to as its total alkalinity. The alkalinity levels in the winter varied from 92.0 to 180 mg/l, whereas in the fall season they ranged from 84.0 to 144.4 mg/l. [75].

Chlorides:

A wide range of chlorides (Cl−) may be found in almost all natural bodies of water, with varying concentrations. There is a correlation between the geochemical conditions of the catchment region and the number of chlorides that are present in a body of water [76]. However, the presence of chlorides in an aquatic system is an indication of pollution by sewage [77]. Over the last twenty years, Dal Lake's chloride concentrations have risen. The findings indicate a sharp rise from a mean concentration of 2–2.7 mg/l in 2007 to 10.3 mg/l in 2017. Elevations in Cl− concentration lead to increased corrosion and damage to the lake vegetation. It also suggests that there is a significant amount of organic garbage in the water, which causes bacteria to use up dissolved oxygen too quickly and harms the lake's ecology. The discharge of raw sewage into the lake is the source of the sharp rise in Cl- content in the lake's waters. Sewage inflow has surged over the last 20 years along with the substantial growth in Dal residents living in the interior of lakes and houseboats [78].

CHANGE IN WATER QUALITIES OF DAL LAKE:

Within the scope of this part, a review of the preceding 10 investigations will be conducted, during which five

parameters, namely pH, alkalinity, calcium, chloride, and nitrate, will be investigated and analysed using a systematic manner. It is essential to have a solid understanding of the usual ranges of these characteristics before going further into the subject matter. This will allow for the accurate drawing of conclusions. The usual ranges are shown in the table that may be seen below.

Table 1: Standard Water Content Range

Content	Normal Range	Impact on Water
PH	6.5-8.5	The bitter taste of water is caused by a high pH, which also reduces the efficiency of chlorine during disinfection.
Alkalinity	20-200 mg/L	Changes in pH that are detrimental to aquatic life may be avoided by increasing the alkalinity of the water.
Calcium	1-35 mg/L	Water with a higher calcium concentration is inappropriate for human consumption, which results in increased frequency of urine.
Chloride	4 mg/L	The presence of a high chloride level imparts a salty flavour to water and has an impact on sewage systems.
Nitrate	10 mg/L	A high concentration of nitrate may lead to nitrate poisoning in living organisms as well as a blue tint of the skin.

An examination of the five primary parameters that will be analysed in accordance with the relevant themes is shown in Table 1. There are five key criteria that will be analysed in order to determine the water quality of Dal Lake. These factors are the pH, alkalinity, calcium, chloride, and nitrate concentrations of the water. In order to conduct an analysis of the parameters that have been mentioned, the values will be compared with the usual parameters that are supplied in the tables that follow. The water quality of Dal Lake will be determined by the comparison study between the normal value and the normal value. [79]

Table 2: Observations

Study	Observations
Bhat & Ali, 2013 **[80]**	Salinity varies spatially and monthly, with greater levels seen around houseboats in Dal Lake.
Parvaiz & Bhat, 2014 **[81]**	Dal Lake's water quality varies per basin.
Bhat & Dar, 2015 **[82]**	Seasonal fluctuations in water quality, however Nehru Park is more susceptible to water contamination.
Wani et al., 2015 **[83]**	Using Pearson's chi square test to determine co-relation: Water contamination is a significant issue.
Wani et al., 2016 **[84]**	Using the Arithmetic Index, it was found that water is unsuitable for human consumption
Dar et al., 2017 **[85]**	Higher concentrations of nitrates, phosphorus, and other components
Qayoom & Tanveer, 2018 **[86]**	Geology and anthropogenic activity are primary causes of deteriorating water quality.

Gull et al., 2021 **[87]**	Urbanisation and anthropogenic activities are responsible for reduced transparency and increased nutrient concentrations.
Rashid et al., 2022 **[88]**	Higher phosphorus content leads to a greater occurrence of weeds.
Bona & Lone, 2023 **[89]**	Poor water quality is influenced by spatial, temporal, and environmental variables.

The pH, alkalinity, calcium, chloride, and nitrate levels were the five most significant factors tracked down in the review. The essential finishes of the review showed that Dal Lake contains an over the top measure of calcium, chloride, and nitrate. Most of these contaminations' inordinate information comes from Srinagar, which affects the ecosystem and water quality. Azolla has multiplied in light of the fact that to the high nitrogen and phosphate focus, covering the greater part of Dal Lake and causing eutrophication. Oceanic life improvement is straightforwardly restrained by higher Body focuses. Due to the lake's serious turbidity, which restrains additional dissolved oxygen from being created by photosynthesis, there are perceptible variety changes, odors, and a protection from light infiltration. The greatest risk to the biology of Dal Lake is turbidity, whether it comes from immediate or backhanded sources. We can rapidly and effectively imagine the effect of various elements and their focuses across Dal Lake catchments on account of GIS. Essentially every bowl in Dal Lake has similar qualities, and in view of the numbers demonstrated previously, nitrate and phosphate tainting is a significant issue in each bowl. Likewise, the examination observed that over the previous forty years, Dal Lake's water quality had fundamentally declined. The biggest danger to sea-going nature comes from rising PH, alkalinity, calcium, and chloride levels. Alkalinity levels rose at the mid year top because of the presence of abundance CO2 from the deterioration cycle interfacing with sewage and family trash. The colossal measure of spillover, rising guest pollution, and uncontrolled sewage removal have truly hurt Dal Lake's water quality. [82]

Table 3: Using a PH Metre, Determine the pH of Dal Lake Water

Study	Ph Value
Bhat & Ali, 2013 **[80]**	8.51
Parvaiz & Bhat, 2014 **[81]**	6.8-8.5
Bhat & Dar, 2015 **[82]**	7-8.9
Wani et al., 2015 **[83]**	7.99
Wani et al., 2016 **[84]**	6.5-8.5
Dar et al., 2017 **[85]**	7.49
Qayoom & Tanveer, 2018 **[86]**	6.5-8.5
Gull et al., 2021 **[87]**	6.2-8.1
Rashid et al., 2022 **[88]**	8.5
Bona & Lone, 2023 **[89]**	6.71-8.18

The "potential of hydrogen," or PH scale, indicates how basic and acidic an alkaline solution is. On the pH scale, 0 is highly acidic, 14 is very basic, and 7 is neutral. The scale runs from 0 to 14. With a pH of 7, water is referred to be a neutral aqueous solution. Water normally ranges from 6.5 to 8.5 because environmental and other socioeconomic variables naturally influence its changes. In light of the aforementioned information, statistics show that Dal Lake water's pH level ranges significantly between 6.5 and 8.5. As a result, the pH level often falls into the neutral aspect range. According to a few studies, Dal Lake's water has an approximate pH of 8, meaning that it is

mostly alkaline. Nonetheless, the differences between the 10 recorded measurements show that the main causes of Dal Lake water's pH swings are small variations in air temperature, seasonal effects, temperature, and human-induced variables. Even the pH changes are caused by differences in day/night and summer/winter temperatures.

Table 4: The Titrimetric Method for Determining the Alkalinity Value of the Water in Dal Lake

Study	Alkalinity
Bhat & Ali, 2013 **[80]**	109
Parvaiz & Bhat, 2014 **[81]**	82
Bhat & Dar, 2015 **[82]**	71.5-96.9
Wani et al., 2015 **[83]**	207.56
Wani et al., 2016 **[84]**	98-180
Dar et al., 2017 **[85]**	171.33
Qayoom & Tanveer, 2018 **[86]**	25-313

A water's alkalinity may be defined as its ability to withstand changes in pH that would otherwise cause the water to become more acidic. To put it another way, alkalinity refers to the capacity of water to neutralise acid. Twenty to two hundred milligrammes per litre is the ideal range for the alkalinity of our water. It may be deduced from the fact that the lake's moderate to high alkalinity has a strong buffering capacity that the average total alkalinity is 116.16 mg/L when taken into consideration. while the total alkalinity levels might range anywhere from sixty to two hundred and thirty milligrammes per litre [90]. The presence of a high quantity of alkalinity in drinking water is typically considered to be beneficial since it ensures that the water is safe for use. A total of 10 evaluations have been conducted, and eight of them have shown that the alkalinity of the water in Dal Lake varies from 25 to 207. Between the north and south sides of Dal Lake, as well as between the east and west sides, there is a wide variety of alkalinity in terms of the habitations. Over the course of the year or in different parts of the world, the alkalinity of the water in Dal Lake does not remain consistent. Because of this, the alkalinity of the water in Dal Lake is extremely remarkable; yet, there are other components that have adversely damaged the water's quality and render it unsafe for human consumption in general.

Table 5: Dal Lake Water's Calcium Content Value as Determined by the EDTA Titmetric Method

Study	Calcium
Bhat & Ali, 2013 **[80]**	17.67
Parvaiz & Bhat, 2014 **[81]**	Normal: 1-35mh/L
Wani et al., 2015 **[83]**	37.41
Dar et al., 2017 **[85]**	32.37
Qayoom & Tanveer, 2018 **[86]**	25-147
Bona & Lone, 2023 **[89]**	15.1-126.83

Between 1 to 35 mg/L, the calcium content of water varies significantly across the United States and other northern hemisphere nations. When calcium levels are high, the kidneys have to work harder to filter it out. An excessive amount of calcium makes you thirsty and urinate a much. All living things' metabolism and bodily functions depend on calcium. The typical calcium concentration of lake water ranges from 4 to 100 mg/L. According to this paradigm, Dal Lake's calcium level ranges widely from 15.1 to 147 mg/L. The average calcium concentration estimated from a subset of research is reported to be 31.88 mg/L. Given this context, it may be assumed that Dal Lake's calcium

concentration is typical; nonetheless, some research has shown that the lake may have an excessive amount of calcium, which might have an impact on the aquatic life and water quality.

Table 6: Dal Lake Water's Chloride Content Level Determined via Argentometric Method

Study	Chloride
Bhat & Ali, 2013 **[80]**	22.02
Parvaiz & Bhat, 2014 **[81]**	Normal
Bhat & Dar, 2015 **[82]**	35.9-42.2
Wani et al., 2015 **[83]**	16.5
Dar et al., 2017 **[85]**	11.33
Qayoom & Tanveer, 2018 **[86]**	12-107
Gull et al., 2021 **[87]**	23-53
Rashid et al., 2022 **[88]**	14.98

The presence of excess chloride ions in drinking water indicates sewage contamination in the water and gives the water a salty flavour. Dal Lake's chloride levels were observed to vary from 12 to 107 mg/L in the current investigation. The mean chloride concentration of Dal Lake water is 19.40 mg/L, which indicates that the water is unsafe for aquatic life and human consumption. The defined standard value system allows for a maximum chlorine content of 4 mg/L in drinking water. The analysis goes on to say that the Nigeen and Hazratbal basins contain notable concentrations of chloride ions, which is a definite indication of the pressure that human activity has imposed.

Table 7: Nitrate Value of Dal Lake Water using Spectrophotometric Method

Study	Nitrate
Bhat & Ali, 2013 **[80]**	308
Parvaiz & Bhat, 2014 **[81]**	292
Bhat & Dar, 2015 **[82]**	301-425
Wani et al., 2015 **[83]**	339.49
Dar et al., 2017 **[85]**	290
Qayoom & Tanveer, 2018 **[86]**	<Normal
Gull et al., 2021 **[87]**	273.7-750

Although nitrates are considered vital nutrients for plants, their overabundance may seriously harm the quality of water. The overabundance of phosphorus and nitrates results in eutrophication, which drastically alters the sorts of plants and animals that dwell there and dramatically increases the development of aquatic plants. Runoff or leaks from fertilised soil, waste water, septic systems, or urban drainage may result in high nitrate levels. The Environmental Protection Agency (EPA) of the United States has declared that 10 mg/L of nitrate is safe to be added to drinking water. But according to the analysis, Dal Lake water's nitrate content ranges from 273 to 750 mg/L. Nitrate concentrations that are too high harm aquatic life and render the water unsafe for human use. Furthermore, the high concentrations of nitrate nitrogen and orthophosphate phosphorus are unmistakable indicators of human activity. The lake's nitrate nitrogen levels vary from 200 to 750 mg/L; because of their close proximity to inhabited regions, the heart of the lake and parts of the Nigeen and Gagribal basins have the greatest concentrations. Conversely, the nitrate nitrogen levels in the Nishat and Hazratbal basins were low [91]

IMPACT OF WATER QUALITY ON LAKE ECOLOGY :

The water in Dal Lake has changed significantly over time, and the lake is now under extreme stress. There's an awful stench coming from parts of the water. One of the main factors contributing to the lake's environmental degradation has been identified as the pressure from human habitations within

and along its edges [92]. In addition to agricultural operations inside foating gardens and converted land, the strain on the lake and its surroundings as potential settlement zones has increased with the growth in population, particularly in metropolitan areas [16]; [91). Population projections indicate a remarkable rise during the preceding twenty years. This has resulted in the illegal annexation and reclamation of large areas of the lake basin's water surface for use as gardens or floating islands, as well as for homes, hotels, and marketplaces [93]. There is still unlawful encroachment going on, despite the fact that the government has boosted its monitoring and taken restrictive measures. Taking into consideration the aforementioned elements, it is evident that the attractive Dal Lake, which is marketed as an aquatic plaza all over the globe, is deteriorating as a result of the increased human influence on its drainage basin. The state of the lake close to the sewage outfalls has cut to the chase of disaster. Despite the fact that pollution rates contrast all through bowls, the effect of developing human exercises is felt all through the whole lake. This is because of an expansion in undesirable variances in the lake, which has made the climate essentially weaken. There is a critical need to restrict the development of sewage from the watershed and to put a conclusive finish to the structure of drifting nurseries, which are as yet occurring in many spots of the lake.

The biodiversity of the lake differs enormously, and these varieties are somewhat self-evident. The bacterial populace has significantly expanded, particularly in the houseboat areas and the regions close to Street and Gagribal, because of a messed up clean system, deficient land the executives rehearses in the close by vegetable fields, and the immediate release of dark waters [94]. Among the most huge phytoplankter species utilized as pollution markers are Cyclotella, Melosira, Microcystis, Achnanthes, Nitzchia, Euglena, Phacus, and Oscillatoria. Zooplankters are viewed as the main and pointer species, and instances of these incorporate Keratella, Brachionus, Chydorus, and Cyclops. [95].

POLLUTION AND ITS SOURCES OF DAL LAKE:

Since rivers, streams, runoffs, and other waste discharges are the sources of pollution that end up in freshwater lakes, these bodies of water are often polluted with a wide variety of contaminants. On a global scale, lake water contamination is a significant concern [96]; [97]). There is now a major water crisis that is affecting people in several regions of the globe [98]. There are billions of people in underdeveloped nations who do not have access to safe drinking water, and there are around two billion people who do not have basic sanitation [99]. There is a high probability that water shortage will spread to other crucial sectors in the not-too-distant future, including the agricultural and energy communities [100]. One of the most significant environmental problems in India is lake contamination. The utilization of non-biodegradable farming items (pesticides, fungicides, herbicides, and insect sprays), the utilization of substance composts rather than natural excrements, the development of enterprises, urbanization, an energy-concentrated way of life, the deficiency of woodland cover, an absence of ecological mindfulness, the shortfall of natural guidelines and guidelines, and

climate improvement plans are contributing elements that are making lakes become seriously dirtied. These lakes exhibit unwanted characteristics such as unattractive colour, aroma, taste, turbidity, organic matter contents, dangerous chemical contents, excessive total dissolved solids (TDS), acids, alkalies, and household sewage, among other characteristics.

Most of the contaminants that make their way into our water bodies come from sources such as domestic wastes, industrial effluents, agricultural wastes, and so on. A significant number of pollutants, in the form of sewage that contains both nutrients and poisons, are discharged into a great number of rivers and other bodies of water. Chemicals and organic compounds are found in industrial effluent, and these substances go into the bodies of a wide variety of aquatic organisms. The soakage pits, septic tanks, manure, rubbish, and other waste products all contribute to the contamination of ground water [101] Most of issues emerge from deficient garbage removal and sterile framework. [102] Oil slicks are risky on the grounds that they influence oceanic life notwithstanding the water. These hazardous oil slicks are welcomed on by the stacking and dumping of petrol and oil in ships close to the shore [103]. Pesticides and other chemicals are found in agricultural waste, which contributes to the contamination of water by filling it with nitrates and phosphates. They are also found in agricultural trash. The presence of these contaminants unquestionably results in an ecological imbalance in the bodies of water. [104]

The water bodies' capacity to detoxify themselves is being diminished by all types of pollution in the water. This implies that they are no longer able to recycle the garbage. Algal blooms and excessive weed growth are caused by nutrients. Even after investing crores of rupees, the outcome is negligible. There are several effects from this problem. The water bodies become shallower and the purity of the water is impacted. The majority of the oxygen that is available is used by algae, which raises the biological oxygen requirement and lowers the dissolved oxygen level. Numerous aquatic plants perish as a result of the lowered rate of photosynthesis. The amount of silt that soil erosion introduces into water bodies lowers the quality of the water. Cow dung fills water bodies with unwanted compounds when it lies on their edge. Water-borne illnesses including cholera, typhoid, diarrhoea, hepatitis, jaundice, dysentery, etc. are caused by contamination in the water supply [105]

Tens of thousands of people visit Dal Lake, the most well-known tourist attraction in Jammu and Kashmir, each year, particularly in the summer. Dal Lake is located in the centre of Srinagar City. It is well renowned for both its rich fishing resources and its beautiful surroundings. important human meddling has deteriorated Dal Lake's environment, which is socially important. The lake's water has become eutrophic due to ongoing climate change and the area's fast economic growth [106]. The reckless and uncontrolled urban expansion that has occurred inside and around the lake has not only resulted in a decline in the chemical quality of Dal Lake, but it has also led to the peripheries of the lake being utilised as a dumping site for solid trash. An unplanned urbanisation has

emerged both inside the lake and in the surrounding area. The nutrient enrichment that occurs as a result of the home-grown sewage from the built-up region is characterised by the reduction in water spread and the increase in aquatic vegetation. One of the factors that has contributed to the deterioration of the lake is the absence of an effective sewage treatment plant. Continuous monitoring is required in order to provide an accurate assessment of the water quality in Dal Lake because of the spatial and temporal change in the hydrochemistry. By monitoring the quality of lakes, it is possible to evaluate the adverse impacts that are caused by human activities and to ensure that management practices are effective in safeguarding the resources that are found in the lake ecosystem [107]; [108]).

It is possible to consider the pollution of Dal Lake as being severe and seemingly never-ending, and it appears to be extremely political. Substances that are essential for the development and reproduction of all living beings are referred to as nutrients. Air, water, and soil are all natural sources of nitrogen and phosphorus, which are two of the most important nutrients. In addition to being found in human and animal waste, nutrients may also be found in chemical fertilisers. Each and every organic substance, including grass clippings and leaves, includes several nutrients. These nutrients are responsible for the development of algae and the depletion of oxygen in the lake, which ultimately results in the creation of dead zones that are devoid of oxygen and no aquatic life [109].

The inputs of nutrients may be classified into two broad categories: point sources and nonpoint sources. The primary sources are sewage treatment facilities, industries, and factories. These facilities release wastewater containing fertilisers straight into a river. While every facility is subject to regulations on the permissible quantity of nutrients that may be lawfully released, breaches may nevertheless occur on occasion. These point source dischargers are widely identified as the primary culprits for oxygen depletion and the formation of dead zones in the Lake. If this assertion is accurate, it is necessary to inquire: What is the underlying reason for the discharge of wastewater into Dal Lake? Water is very precious, with some considering it to be the modern equivalent of oil in society. If we acknowledge this as truth, it is imperative that we save and use our treated wastewater with utmost caution and efficiency. Therefore, it is logical and reasonable (in my opinion) to repurpose the wastewater now being released into Dal Lake and use it again. The process of recycling water conserves primary water resources in reservoirs and aquifers, while also reducing the discharge of treated effluent into public water bodies like Dal Lake. Treated wastewater can be utilised for various purposes currently served by untreated water, including watering lawns, parks, gardens, golf courses, and farms; extinguishing fires; washing vehicles; managing dust; cooling industrial machinery, towers, and nuclear reactors; producing concrete; and cleaning streets. My argument is that when we get really thirsty, we will discover more applications for appropriately processed and purified wastewater. However, it is certain that we will only use this treated wastewater for the sole goal of satisfying our thirst. [110].

An observation revealed that significant amounts of wastewater are being discharged into Dal Lake on a regular basis from human settlements, agricultural activities, and houseboats. This has resulted in severe water contamination in Dal Lake. There has been a sudden surge in the quantity of houseboats and unauthorised structures in Dal Lake. There has been an upsurge in agricultural methods in several regions around the lake. The majority of houseboats use lake water for various purposes, while the waste generated from sewage and sullage is immediately released into the lake from these houseboats. Vegetable scraps and paper, which are solid trash, are disposed of in the lake. The local villagers have built toilets inside the lake.

Sources:

Dal Lake is subject to pollution from both point sources and non-point sources. The point sources include of (i) sewage and other human waste originating from houseboats and residential dwellings, and (ii) sewage outfalls originating from neighbouring localities, including some tourist destinations. The non-point sources include the discharge from agricultural fields and the erosion of soil from the catchment regions.

Point Sources

- Untreated sewage: Primary culprit, directly discharging harmful pollutants.
- Industrial effluents: Can contain heavy metals, toxic chemicals, and organic matter.
- Wastewater from houseboats and hotels: Contributes to nutrient and organic load.

Non-point Sources

- Agricultural runoff: Fertilizers and pesticides contribute to nutrient enrichment and eutrophication.
- Soil erosion: Increases sedimentation, reducing water clarity and impacting aquatic life.
- Waste disposal: Littering and illegal dumping pollute the lake with plastics and other debris.
- In the summer, the level of pollutants rises due to the presence of approximately 1700 houseboats and hotels accommodating an additional five lakh people annually. [111]

Table 8: Showing different types of effluent discharge

Site	Name of water stream/Nallah draining into Dal Lake	Types of effluents discharged
Nishat pipe line bund	Drain	Sewage
Sheikh mohalla Brein	Sheikh Kul/Nallah	Agricultural runoff originates from suspended contaminants such silt, mud, sand, and clay as well as soaps and detergents.
Laam village	Gam kul	Water pollution can be caused by soaps, detergents, agricultural runoff, and suspended contaminants such muck, silt, clay, and sand.
Dalgate mohalla	Drain	Sewage
Khwaja	Khwaja Yarbal	Human faeces, Soaps, Detergents

mohallah		
Entry of Telbal Nallah	Telbal Nallah	Water pollution can be caused by sewage, soaps, detergents, agricultural runoff, and suspended contaminants such muck, silt, clay, and sand.
Brarinambal	Brarinambal drain	Agricultural runoff
Saidakadal	Nallah	Human faeces, Soaps, Detergents
Hotel Heemal	Discharge pipe	Sewage

MANAGEMENT OF POLLUTION IN DAL LAKE:

Sewage and solid waste management:

The pollution of Srinagar's Dal Lake fills in as a conspicuous illustration of how human action has hurt the lake hopelessly, keeping it from recuperating normally. Infringement, silting, weed invasion, and the populace's enormous scope release of fluid and strong waste affect the lake. Thus, strong waste is one of the essential wellsprings of the refuse that has spilled over into the lake [112]; [113]). Besides, the use of strong waste parts has prompted the statement of critical measures of oxygen, bringing about a decrease of the dissolved oxygen focus in lake waters. Anaerobic circumstances have likewise been welcomed on by this peculiarities in some of the lake's areas [114].

There are many houseboats in Dal Lake that are right now being used. The vast majority of these are secured from Dal Entryway to Nehru Park, which is across Lane Street, with the end goal of the travel industry and other business pursuits. These boats are involved by guests and their proprietors during the vacationer season, and the guests toss the produced strong waste into the lake. These houseboats subsequently transform into a ceaseless wellspring of pollution that traverses Dal Lake [16]. In the lake districts, notwithstanding these houseboats, various populated settlements have additionally been laid out. Furthermore, these towns contribute a lot of strong waste, which in the long run sullies the lake and makes it disintegrate [91]. The nurseries, business structures and markets that line the lake's edge, as well as the encompassing inhabitation, all have a section in the littering and resulting removal of strong waste in the lake's waters, either straightforwardly or through channels that stream into it. The recently expressed point sources are extra wellsprings of pollution.

The inorganic components, particularly nitrogen and phosphorus, give the supplements that lead to the development of weeds, while the natural parts of rubbish and food squander add to the lake's absence of dissolved oxygen levels. One more component that adds to the lake's general state of mind is the drifting garbage, which comprises of things like paper, plastic sacks, glass bottles, metal jars, and other metal pieces. Dal Lake had been used as a holding region for a lot of approaching waste, including crude human dung, for a long time [115]. Decentralized sewage treatment and a sewerage foundation are two parts of a wastewater stream control procedure that has been created and carried out. Sewage treatment utilizing a fluidized aerobic bed (FAB) has been

supported as opposed to siphoning the wastewater to a solitary spot where it very well might be dealt with. The remarkable climatic circumstances, the deficiency of enormous lots of land, the absence of electrical power, and the unpleasant territory all assumed a part in this choice [112]; [116]. This system produces effluents that meet the necessities for release into the lake by utilizing synthetic treatment, tube pilgrims, rotators, and both connected and scattered microbial development in bioreactors. Included is the plan for a basic siphoning system.

The Other Hydro Energy Focus of the Indian Institute of Technology (IIT), Roorkee, has now proposed three sewage treatment offices (STPs) [117], Work at three areas encompassing the lake. The areas of Habak, Hazratbal, and Lam are close to the lake and are home to the recently referenced areas. The lake gets treated wastewater from the Sewage Treatment Plants (STPs). Table 9 shows a huge contrast in the physio-compound properties of treated and untreated sewage.

Table 9: Assessment of the raw sewage and processed sewage quality at the Sewage Treatment Plant (STP) at Hazratbal (Qayoom et al., 2021) [116]

Parameters	Inflow	Outflow
COD (mg/l)	280	56
BOD (mg/l)	100	20
Total Solid (mg/l)	415	83
TDS (mg/l)	275	55
TSS (mg/l)	137	28
pH	6-6.5	7.8
DO (mg/l)	<1	<1.6
Nitrogen(mg/l)	45	9
Ammonia(mg/l)	15	3
Chloride(mg/l)	75	15

Dal Lake requires more Sewage Treatment Plants (STPs) and effective management strategies to handle the discharge of solid waste in its surrounding area. Hyper-eutrophic regions such as Nehru Park and Nigeen basin need the installation of new Sewage Treatment Plants (STPs) and the improvement of the existing ones. The inefficiency and seepage issues of these Sewage Treatment Plants (STPs) have resulted in a rise in lake eutrophication [116]. At-site treatments might include the establishment of small-scale waste-water treatment facilities to serve communities or individual houses.

Deweeding & Harvesting:

Dal Lake is home to a diverse and vibrant macroflora community that, in some places, has grown into thick layers that form an almost impenetrable mass [118]. The species that are covered the most incorporate those that are lowered and those that float, which are turning into a disturbance. There are different lucky variables that add to Dal Lake's profusion of macrophyte greenery. These incorporate the bowl's shallow profundity and slow slant, its supplement rich dregs, optimal temperatures and light levels for development, the shortfall of waves, and the presence of various lasting species that are all around adjusted to actually take advantage of the ongoing natural circumstances. [119]. Aquatic macrophyte populations are widely acknowledged as being "habitat opportunists," meaning that once they get established in a certain lake or area, it becomes difficult to remove them. An argument has been put out to remove excess macrophyte biomass from Dal Lake by mechanical harvesting in order to enhance its utilisation for water sports, navigation, and other necessary activities.

Nevertheless, it is undeniable that in some areas of the lake, there is a substantial proliferation of aquatic vegetation, which significantly detracts from the overall aesthetic quality of the environment. Regrettably, the importance of macrophytes in the freshwater environment, where they perform different essential activities, has been entirely overlooked while advocating for the use of machinery for weed control. It ought to be featured that, instead of dispensing with all macrophyte vegetation from Dal Lake, the most reasonable and effective game-plan is confine its development. Macrophytes are generally utilized as reliable marks of defilement. By working as supplement siphons and biological sinks, they effectively separate minerals from the residue supplement pool, adding to the abatement of pollution. Macrophytes fill various needs for the Dal inhabitant populace, like food, creature feed, and restorative plants. In the amphibian pecking order, macrophytes are the essential wellspring of food and offer fish and other macrofauna the best conditions for mating, resting, and stowing away. Additionally, macrophytes support substantial amounts of periphyton, which is essential for the survival of numerous aquatic animals. Macrophytes may serve as alternatives for both inhibiting sediment suspension and oxygenating water via photosynthesis. However, it remains a verifiable truth that the substantial proliferation of large-scale plant life in a lake hinders transportation, obstructs irrigation, intensifies sedimentation by capturing fine particles of soil, and impacts recreational activities. Therefore, it is necessary to assess the benefits and drawbacks of using mechanical harvesting as a means of managing aquatic vegetation. Subsequently, the most advantageous approach should be chosen for the system, while avoiding any unintended negative consequences that might be more detrimental and challenging to manage. One of the strategies used to rehabilitate lakes is mechanical weed harvesting, which involves removing biomass from the lake. This approach has been successfully used to some degree in Europe and the USA. Chemicals are often used in conjunction with weed picking in several circumstances. The use of chemicals in Dal Lake is not recommended due to the many purposes for which its water is used.

The most logical approach to managing aquatic plants is via control rather than complete removal. Avoid complete elimination of plant vegetation and extensive harvesting under any circumstances. Shallow lakes, such as Dal Lake, are very vulnerable to transitioning from a stable vegetative condition to a non-vegetative one. The vegetative stage exhibits more resilience to shocks, nevertheless, excessive removal of weeds may disrupt their stability and result in the formation of turbid waterways characterised by algal blooms [19]. Harvesting weeds has to be selective, that is, restricted to certain zones exclusively. Lake regions that are useful for food plants, fish, and fodder should not be subjected to repeated harvesting. Harvesting need to occur before to a plant's flowering, fruiting, or propagule development. When harvesting procedures include any of the following, regular monitoring should be started: To analyse differences in the cover and frequency of various species, vegetation

maps must be created. It is possible to draw a connection with previous vegetation maps. The use of satellite imagery and aerial photos will be very beneficial. Periodically, the effectiveness of both human and machines must be observed. It is necessary to keep an eye on the regrowth of plants and modifications to the community's structure. The phenology of several aquatic plants has to be documented. Following de-weeding, any changes in the dominant species must be routinely recorded.

Lake Sediment Dredging:

Since the dregs has absorbed an enormous amount of nitrogen and phosphorus during the long term time of rising eutrophication, diminishing the supplement load in the watershed by gathering and treating sewage might not have quite a bit of an effect on working on the nature around Dal Lake [91]. Since any abatement in the amount of external stacking is every now and again offset by how much inside stacking, the lake's reaction to the decrease in how much supplements entering the system from the encompassing region is consequently restricted. Regardless, a huge piece of these supplements are held in silt and ultimately delivered once more into the water. Somewhat, biological life can retain supplements from catchment regions and other outside sources, yet not altogether. Albeit interior stacking is a crucial wellspring of supplements in Dal Lake, there is little data on how much supplements that are set free from the residue in the lake.

Because of the profound dregs water association, the presence of a lot of strong landmass along the northeastern line, and the expected huge impact of siltation, the normal working of the Dal Lake ecosystem is harmed [120]. Digging of lake dregs can be utilized as a recovery strategy to accomplish the accompanying targets: evacuation of supplement rich residue; developing of silted lake districts to improve water stream; expulsion of strong land mass and sandbars; and decrease of rising vegetation. Digging can be viewed as a fruitful way to deal with lake rebuilding on the off chance that a pre-execution evaluation of the lake climate is finished, proficient hardware is chosen, and removal areas are recognized preceding the digging system initiating. In this manner, numerous components should be considered while planning the lake extending project, for example, the degree of the developing relying upon the area that will be dug out, the dumpsite, and the utilization of the lake region that will be dug out.

Development of Shoreline:

The visibility of the coastline of a body of water is a clear and definitive sign of the biological condition of that water body, and Dal Lake is no exception. The stretch of coastline, namely from Dal-gate to Naseem Bagh, has seen significant development over the years, becoming a highly sought-after location for both tourist-related businesses and residential growth [121]. In order for any management plan pertaining to Dal-Nagin Lake to be effective, it is necessary to thoroughly examine and visualise the influence of both the tourist and local communities on the lakes [122]. An assessment of the anticipated use and consequences must be conducted to identify the potential development of the coastline from a clear standpoint.

Research and Monitoring Programme

More accentuation is being put on

the way that there is right now no unmistakable arrangement set up for the extensive observing and organization of the lake. Despite the implementation of afforestation programmes, there are still several locations within the basin where erosion processes persist at a high intensity. The little silt basin located at the northern extremity of the lake is unable to completely obstruct the influx of silt and often becomes filled. The dredging for silt removal has resulted in an invasion of weeds and plankton. The removal of invasive macrophytes, whether done manually or by harvesters, has not shown positive results. The proliferation of weeds accelerates and creates obstacles to both navigation and enjoyment. The conservation efforts focus on afforestation of the catchment area to regulate the passage of silt, dredging the lake, and eliminating weeds. The outsider species intrusion, exorbitant siltation and sewage release, territory misfortune, and rivalry with additional economically valuable species adversely affect the local Dal verdure and untamed life. In any case, checking of biodiversity in the space has been considered irrelevant [123]; [124]). The biological variety of the lake is inadequately documented, except for a couple of solitary bird counts and studies on a couple of animal categories. Various subjects, for example, species counts, creation information, supplement pools, food web properties, species interdependencies, eating and reproducing designs, natural surroundings elements, and significantly more, require long haul examination. This is fundamental to understand the impacts that different administration techniques have on the biological assortment and general wellbeing of the lake. Considering this, an exhaustive report technique for the lake holding is required, one that tends to the board rehearses, rebuilding drives currently in progress, and holes in our understanding of the Dal Lake climate. This solicitation is educational on the grounds that it shows that further examination is fundamental.

Public Awareness Program:

Any task's capacity to succeed relies upon the inclusion, help, and joint effort of the individuals who are believed to be "Undertaking Impacted." Since the neighborhood local area would be the ones straightforwardly impacted by the venture's execution, this sort of venture genuinely should be participatory and have their help. This requires the age of data at all levels in regards to the requirement for the preservation project, its goals, and how it would work on the quality of life and everyday environments for the nearby local area [125]. It ought to likewise contain insights concerning the lake's current area, the need to clean it, how to protect the rich biodiversity it contains, and how to keep up with the regular harmony of the lake system. It ought to likewise inform individuals concerning the drives being taken by the public authority and different associations to preserve lakes, as well as how they might get involved to make this a development driven by individuals. [126]. It is also important that it offer information on the progress that has been made in the implementation of the project in order to instill confidence in the indigenous community.

CONCLUSION:

The literature review has provided a chance to conduct an investigation into the water quality of Dal

Lake, which has been a topic of interest. Given the findings of the assessment, it seems that the water quality in Dal Lake is progressively deteriorating. Because of the rise in pollution and pollutants caused by humans, the biological oxygen demand (BOD) in a particular lake area has grown, which reduces the amount of dissolved oxygen in the water and has an impact on aquatic organisms. A pH level that is unmatched and alkalinity that is interrupted have both had a detrimental impact on the overall quality of the water. In this perspective, the following initiatives may be considered a reformative and creative measure or measures to conserve and sustain the recreational and ecological value of Dal Lake, as well as the water quality, which would include the following:

- Implementation of a methodical and suitable urban planning strategy for the management of trash and garbage.
- Requirement for a distinct plan to rejuvenate the environment, ensure the survival of ecosystems, and maintain ecological equilibrium.
- Public-private collaboration and comprehensive strategy for water management.
- Efforts should be made to prevent neighbouring basins from discharging rubbish into the water of Dal Lake.

The conservation of water bodies in Kashmir is a significant obstacle for the authorities. Significant financial resources are required for this endeavour due to the rising expenses associated with new technology and human resources. Resolving this issue and offering the accompanying administrations falls inside the domain of the Lakes and Waterways Development Authority (LAWDA), an approved body. Throughout the course of recent years, there has been a lot of human burden on Dal Lake's water quality. Various things, including houseboats, sewage treatment plants (STPs), inns, agrarian endeavors, drifting nurseries, lake infringement, and different wellsprings of pollution, have hurt the lake's excellence and water quality. Hindering substances like phosphates, chlorides, and nitrates have become altogether more pervasive over the long run. All out phosphorus focus expanded fundamentally, from 0.1 to 0.4 mg/l in 1997 to around 6 mg/l in 2017. Equivalently, how much chlorides in the water has additionally expanded essentially, ascending from 2-2.7 mg/l in 2007 to 10.3 mg/l in 2017. Different components like magnesium and calcium have additionally been moving ascending in the lake. Lake waters are as of now not fitting for drinking or domestic use because of changes in pH and alkalinity levels. How much dissolved oxygen in the lake has essentially diminished over the most recent couple of many years. Yearly, the lake's dissolved oxygen (DO) levels diminished from 7.4 mg/l in 1997 to 6.9 mg/l in 2017. Many parts of the lake have encountered hyper-eutrophication, which has genuinely upset the ecosystem of the lake. These elements have incredibly impacted the lake water quality, which won't return all alone. The possibilities of the lake enduring are very thin on the off chance that reasonable and brief arrangements are not set up. Thusly, it is basic to address the worries about lake rebuilding, the executives, and conservation at the earliest opportunity, including the local area and the

administering bodies. The development of a participatory protection technique that focuses on the rebuilding of both water quality and amount while considering the interests of all interested individuals is basic to prevent the lake from passing on too early. There are various parts of the hydrology, science, and geography of the lake that expect exploration to ensure the lake's practical administration. One dismissed area of exploration that requirements center is the assessment of what pollution and modifications in water quality mean for the lake's biodiversity..

RECOMMENDATIONS:

Although Dal Lake is a natural and attractive tourist attraction, it is also the natural habitat of a large number of living animals. However, the situation may soon change as a result of a growth in the number of tourists and the population. As a result of the fact that this location does not have the contemporary equipment necessary to collect, transport, store, process, and dispose of solid waste, the population is rising, and the number of tourists is increasing, which might result in the generation of an increasing amount of solid trash. The Lake and Water Development Authority (LAWDA), the Society of Municipalities (SMC), and civilised residents should take into account the following proposals in order to preserve and safeguard this resource for the future:

- Due to the fact that the majority of the wastes produced inside Dal Lake were composed of recyclables and things that might be composted, it is imperative that recycling and composting be given priority. This will ensure that only a small fraction of the solid waste is sent to the disposal facility.
- Separate trash containers should be made available for the purpose of on-site segregation of biodegradable, combustible, and recyclable wastes that are created in the Dal Lake region. It is recommended that the number of visitors that visit the lake be regulated, since an increase in the number of tourists would result in an increase in the amount of garbage generated.
- L.A.W.D.A. and SMC have to ensure that the temporary storage facilities are maintained in such a way that they do not contribute to the creation of unclean and unhealthy circumstances. This is especially important in the vicinity of Dal Lake. It is highly recommended that the authorities belonging to the Health Department investigate this situation with great attention.

FUTURE RESEARCH:

Even though Dal Lake has been the subject of several research, the majority of them concentrate on certain features of the lake. Generally, there are very few research on management and monitoring from the perspectives of feasible development and management. Studies on limnology reveal the chemistry of water, sediment, and planktons. Concentrating on the biology of the lake requires covering a scope of Felds. The land studies of the lake bed and catchment, hydrological investigations that think about the more grounded meteorological design of the lake catchment, the impacts of snowfall, dissolving, and precipitation on transient

stream into the lake, the job of groundwater stream from the lake's adjoining region to it, as well as the other way around are a portion representing things to come research needs. a clarification of the springs in the watershed and their highlights; The effect of exercises in the catchment on the volume of surface and groundwater streaming into the lake; exhaustive utilizations of the watershed that recognize soil types, height, waste lines, land use, and their impact on streams in the channels that fill the lake; pressure driven models of the lake, the catchment, and the lake flow Deciding the system's general water balance is important prior to investigating different components that are reliant upon the hydrology of the water body.

Since carbonate and volcanic rocks make up the majority of the Dal Lake's catchment region, the increased content of calcium and bicarbonate also suggests that the denuded catchment area has undergone extensive chemical weathering. Similar to calcium, magnesium ions may also be released by the chemical weathering of minerals such as dolomite, pyroxene, and olivine, but at lesser concentrations. This might be because magnesium is not as abundant in the geological realm as calcium is. The following primary categories of contaminants were found to regularly enter Dal Lake. Agricultural runoff, soaps and detergents, sewage and sullage, Solid wastes (paper, plastic, polythene, rusted metal), animal waste trash from nearby hotels, restaurants, and houseboats; soil erosion from watershed regions. To reduce these contaminants, the following actions have to be taken. [127]

- A single treatment facility for all houseboats, preventing the direct disposal of all waste into Dal Lake
- The ongoing removal of extra weeds from Dal Lake.
- Building STPs at every input channel
- Reforestation in the region of catchment
- Farmlands in the watershed region may not use commercial fertilisers (nitrogen and phosphorus) or animal dung.
- Management of grazing animals in the catchment area. It is advisable to motivate them to create and execute nutrient management strategies in order to minimise the overuse of fertilisers.

REFERENCES

1. Singh, S.P., D. Pathak, R. Singh, 2002. Hydrobiological studies of two parts of Satna (M.P), India. Eco. Env. and Cons., 8: 289-292.
2. Kumar N (1997). “A View on Freshwater Environment”. Ecology, Environment & Conservation; 3: 3-4
3. Mahananda HB, Mahananda MR, Mohanty BP (2005). “Studies on the Physico-Chemical and Biological Parameters of a Fresh Water Pond Ecosystem as an Indicator of Water Pollution”. Ecology, Environment & Conservation; 11 (3-4): 537-541.
4. Venkatesharaju K, Ravikumar P, Somashekar RK, Prakash KL (2010). “Physico-Chemical and Bacteriological Investigation on the River Cauvery of Kollegal Stretch in Karnataka”. Journal of Science, Engineering and Technology; 6(1): 50-59
5. Singh P (2004). Geological Work of Water and Physiographic Features In: Parbin Singh’s Text

Book of Engineering and General Geology.7thed., M/S Sanjeev Kumar Kataria Publishers Nai sarak, Delhi, India. Pp54-170

6. Hamnera S, Anshuman T, Kumar R, et al. (2006). "The Role of Water Use Patterns and Sewage Pollution in Incidence of Water Born/ Enteric Diseases along the Ganga River in Varanasi India". Int. J Environmental Health Research; 16(2): 113-132.
7. Evaluation of Operation and Maintenance of Sewage Treatment Plants in India (2007). Central Pollution Board, Ministry of Environment and Forests. Available from http//: www.en.wikipedia.org/water pollution. Retrieved on 15-09-2013.
8. WHO (2011). Guidelines for Drinking Water Quality.Vol. 1 & II recommendations, 4th ed. Available from http//: www.who.int/../en/ Accessed on 28-11-2013.
9. Akpofure EA, Efere ML, Ayawei P (2000): The Adverse Effects of Crude Oil Spills in the Niger Delta. Urhobo Historical Society journal; 10: 10-14
10. Cook JL, Baumann P, Jackman JA, Stevenson D. "Pesticides Characteristics that Affect Water Quality". Available From http://insects.tamu.edu/extension/bulletins/water/water_01.html. Retrieved on 20-12-2014
11. Agrawal A, Pandey RS, Sharma B (2010). Water Pollution with Special Reference to Pesticide Contamination in India. Journal of Water Resource and Protection; 2 (5): 1-17
12. Burton GA, Pitt R (2001). "Stormwater Effects Handbook: A Toolbox for Watershed Managers, Scientists, and Engineers". New York: CRC/Lewis Publishers
13. Schueler TR (2000) "Cars Are Leading Source of Metal Loads in California." (Reprint) In: The Practice of Watershed Protection.Center for Watershed Protection. Ellicott City, MD. Available From http://www.cwp.org/store/guidance.htm. Accessed on 09-03-2014
14. Selna R (2009). "Power Plant has no Plans to Stop Killing Fish."San Francisco Chronicle. Available From http://www.sfgate.com/cgi-bin/article.cgi? Accessed on 09-03-2014
15. Jammu and Kashmir Lakes and Waterways Development Authority.Available From http://www.jklda.org. Assessed on 20-12-2013
16. Ganaie, T. A., & Hashia, H. (2020). Lake sustainability and role of houseboats: Impact of solid waste and sewage of houseboats on the ecology of Dal Lake (pp. 341–357). Springer
17. Rouf Ahmad Bhat, N. Mushtaq, Mohammad Aneesul Mehmood, Gowar Amid Dar, 2017. Current status of nutrient load in Dal Lake of Kashmir Himalaya. Journal of Pharmacognosy and Phytochemistry 6(6): 165-169
18. Rashid, I., Romshoo, S. A., Amin, M., Khanday, S. A., & Chauhan, P. (2017). Linking human-biophysical interactions with the trophic status of Dal Lake, Kashmir Himalaya, India. Limnologica, 62, 84–96. https://doi.org/10.1016/j.limno.2016.11.008
19. Masoodi, S., & Kundangar, M. R. D. (2018). Environmental impact assessment studies on Dal Lake Kashmir. International Journal of Engineering Research Mechanical Civil Engineering, 3, 2456–1290
20. Sharad JK, Agarwal PK, Singh VP. Hydrology and water resources of India. Springer, 2007
21. ENEX. Study of the pollution of Dal

Lake, Srinagar Kashmir India. ENEX Consortium Report ID2. 1987; New Zealand

22. Bhateria, Rachna & Jain, Disha. (2016). Water quality assessment of lake water: A review. Sustainable Water Resources Management. 2. 10.1007/s40899-015-0014-7.
23. Seth R, Mohan M, Singh P, Singh R, Dobhal R, et al. (2014) Water quality evaluation of Himalayan Rivers of Kumaun region, Uttarakhand, India. Appl Water Sci. 6: 137-147.
24. Kanakiya, R.S., Singh S.K., Sharma J.N., (2014)," Determining the Water Quality Index of an Urban Water Body Dal Lake Kashmir, India" IOSR Journal of Environmental Science, Toxicology and Food Technology Volume 8 (12), pp 64-71.
25. Mushtaq, J., Dar, A. Q., & Ahsan, N. (2020a). Spatial–temporal variations and forecasting analysis of municipal solid waste in the mountainous city of north-western Himalayas. SN Applied Science, 2, 1–18. https://doi.org/10.1007/S42452-020-2975-X/FIGURES/8
26. Khan, F. A., & Ansari, A. A. (2005). Eutrophication: An ecological vision. Botanical Review, 71, 449–482
27. Zargar, U. R., Chishti, M. Z., Yousuf, A. R., & Fayaz, A. (2012). Infection level of monogenean gill parasite, Diplozoon kashmirensis (Monogenea, Polyopisthocotylea) in the Crucian Carp, Carassius carassius from lake ecosystems of an altered water quality: What factors do have an impact on the Diplozoon infection? Veterinary Parasitology, 189, 218– 226. https://doi.org/10.1016/j.vetpar.2012.04.029
28. Ali, U. (2019). Impact of anthropogenic activities on Dal Lake (Ecosystem/conservation strategies and problems). International Journal of Multidisciplinary Research, 6, 125–128
29. Kundangar, M. R. D., & Abubakar, A. (2004). Thirty years of ecological research on Dal Lake Kashmir. Journal of Research Development, 4, 45–57
30. Ahmad, T., Gupta, G., Sharma, A., Kaur, B., Alsahli, A. A., & Ahmad, P. (2020). Multivariate statistical approach to study spatiotemporal variations in water quality of a Himalayan urban fresh water lake. Water (switzerland), 12, 2365. https://doi.org/10.3390/W12092365
31. Mushtaq, J., Dar, A. Q., & Ahsan, N. (2020b). Physio-chemical characterization of municipal solid waste and its management in high-altitude urban areas of North-Western Himalayas. Waste Dispos Sustain Energy, 22(2), 151–160. https://doi.org/10.1007/S42768-020-00040-1
32. Parvaze, S., Parvaze, S., Haroon, S., Khurshid, N., Khan, J. N., & Ahmad, L. (2016). Projected change in climate under A2 scenario in Dal Lake Catchment Area of Srinagar City in Jammu and Kashmir. Current World Environment, 11, 429–438. https://doi.org/10.12944/cwe.11.2.11
33. Romshoo, S. A., Dar, R. A., Rashid, I., Marazi, A., Ali, N., & Zaz, S. N. (2015). Implications of shrinking cryosphere under changing climate on the streamfows in the lidder catchment in the Upper Indus Basin, India. Arctic, Antarctic, and Alpine Research, 47, 627–644. https://doi.org/10.1657/AAAR0014-088
34. ATALO, Y. (2020). Evaluation Of

Pollutants Load In Urban Stormwater At Lake TanaWatershed: The Case Study In Bahir Dar City, Ethiopia (Doctoral Dissertation)

35. Kumar R, Parvaze S, Huda MB, Allaie SP. The changing water quality of lakes-a case study of Dal Lake, Kashmir Valley. Environ Monit Assess. 2022 (2) 26; 194(3):228.
36. I. Gull, A. Abubakr, M. H. Balkhi, T. H. Shah, B. A.Bhat, F. A.Bhat & H. Qadri, Changes in Physico-Chemical Parameters at Different Sites of Dal Lake, Kashmir, The Pharma Innovation Journal, 10, 12, 281-288 (2021)
37. Trivedy, R.K & Goel, P.K., 1986, Chemical and biological methods of water pollution studies, Kharad: Environmental Publications.
38. Sarwar, S. G., & Zutshi, D. P. (1987). Primary productivity of periphyton. Geobios, 14, 127–129
39. JKLAWDA. (1997, 2005, 2010). Jammu and Kashmir lakes and water ways development authority. Technical Reports on Dal Lake, Srinagar.
40. Gulzar, B., Balkhi, M. H., Abubakr, A., Bhat, F., Asimi, A. O., & Bhat, B. A. (2020). Distributional pattern of algal/ plankton groups in relation with water quality of Himalayan Dal lake, Kashmir, India. Journal of Pharmacognosy and Phytochemistry, 9, 736–740
41. Lucas, L. V., Thompson, J. K., & Brown, L. R. (2009). Why are diverse relationships observed between phytoplankton biomass and transport time? Limnology and Oceanography, 54, 381–390
42. Kanakiya, R. S., Singh, S.K & Sharma, J.N., 2014, Determining the Water Quality Index of an Urban Water Body Dal Lake, Kashmir, India, IQSR Journal of Environmental Science, Toxicology and Food Technology (IQSR-JESTFT).
43. Esmaeili, H.R & Johal, M.S., 2005, Study of physico-chemical parameters of water of Gobindsagar reservoir, India. In: M.S. Johal (Ed), Proceedings of the national seminar "New trends in Fishery Development in India". Chandigarh: Punjab University, pp. 173-177.
44. Khanday, S. A., Romshoo, S. A., Jehangir, A., Sahay, A., & Chauhan, P. (2018). Environmetric and GIS techniques for hydrochemical characterization of the Dal lake, Kashmir Himalaya, India. Stochastic Environmental Research and Risk Assessment, 32, 3151–3168. https://doi.org/10.1007/s00477-018-1581-6
45. Sharma, J. N., Kanakiya, R. S., & Singh, S. K. (2015). Limnological study of water quality parameters of Dal lake, India. International Journal of Innovation Research and Science Engineering Technology, 4, 380–386.
46. Trisal, C. L. (1987). Ecology and conservation of Dal Lake, Kashmir. International Journal of Water Resources Development, 3, 44–54. https://doi.org/10.1080/07900628708722332
47. Zutshi, D. P., & Ticku, A. (1990). Impact of mechanical deweeding on Dal Lake ecosystem. Hydrobiologia, 200–201, 419–426. https://doi.org/10.1007/BF02530359
48. Kremleva, T. A., & Moiseenko, T. I. (2017). Evaluation of the pH bufer capacity of natural lake waters in western Siberia: Criteria of resistance to acidifcation. Geochemistry International, 55, 559–568. https://doi.org/10.1134/S0016702917060052
49. Kaul, V. (1977). Limnological survey of Kashmir lakes with

reference to trophic status and conservation. International Journal of Ecology and Environmental Sciences, 3, 29–44

50. Chashoo, H. F., Abubakr, A., Balkhi, M. H., Shah, T. H., Malik, R., Bhat, B. A., & Gul, S. (2020). Impact of sewage treatment plant efuent on water quality of Dal Lake, Kashmir. India. International journal of chemical studies, 8, 1915–1921
51. Ruhela, M., Wani, A. A., & Ahamad, F. (2020). Efciency of sequential batch reactor (SBR) based sewage treatment plant and its discharge impact on Dal Lake, Jammu & Kashmir, India. Archive of Agriculture Environmental Science, 5, 517– 524. https://doi.org/10.26832/24566632.2020.0504013
52. Das, R., Samal, N. R., Roy, P. K., & Mitra, D. (2006). Role of electrical conductivity as an indicator of pollution in shallow lakes. Asian Journal of Water, Environment and Pollution, 3, 143–146.
53. Ozguven, A., & Demir Yetis, A. (2020). Assessment of spatiotemporal water quality variations, impact analysis and trophic status of Big Soda Lake Van, Turkey. Water, Air, and Soil Pollution, 231, 1–17. https://doi.org/10.1007/s11270-020-04622-x
54. Stenfert Kroese, J., Batista, P. V. G., Jacobs, S. R., Breuer, L., Quinton, J. N., & Rufno, M. C. (2020). Agricultural land is the main source of stream sediments after conversion of an African montane forest. Science and Reports, 10, 14827. https://doi.org/10.1038/s41598-020-71924-9
55. Grobbelaar, J.U.. (2009). Turbidity. 10.1016/B978-012370626-3.00075-2.
56. Shah, J. A., Pandit, A. K., & Shah, G. M. (2019). Physico-chemical limnology of lakes in Kashmir Himalaya, India. Journal of Environmental Science and Technology, 12, 149–156. https://doi.org/10.3923/jest.2019.149.156
57. Lohri, C. R., Rodić, L., & Zurbrügg, C. (2013). Feasibility assessment tool for urban anaerobic digestion in developing countries. Journal of Environmental Management, 126, 122–131. https://doi.org/10.1016/j.jenvman.2013.04.028
58. Kundangar, M. R. D. (2003). Deweeding practices in Dal Lake and their impact assessment studies. Nature Environment and Pollution Technology, 2, 95–103
59. Pahwa, D.V & Mehrotra, S.V., 1966, Observations on Fluctuations in the abundance of plankton in relation to certain hydro biological condition of river Ganga, Preceedings of the National Academy of Sciences, Vol, 36(2), pp. 157-189.
60. Badola, S.P & Singh, H.R., 1981, Hydrobiology of the river Alaknanda of the Garhwal Himalaya -Indian Journal of Ecology, Vol, 8(2), pp. 296-276.
61. Vasisht, H.S & Sharma, K., 1975, Ecology of atypical urban pond in Ambala city of Haryana - Indian Journal of Ecology, Vol, 2(1), pp. 79-86.
62. Latif, Usman & Dickert, Franz. (2015). Biochemical Oxygen Demand (BOD). 10.1007/978-1-4939-1301-5_2.
63. Ohle, W. (1934). See-Erz, Rosträhren und verwandte Konkretionen. Geologische Rundschau, 25, 281–295
64. Ishaq, M., & Kaul, V. (1988). Calcium and Magnesium in Dal Lake, a High Altitude Marl Lake in Kashmir Himalayas. Internationale Revue Der

Gesamten Hydrobiologie und Hydrograhie, 73, 431–439. https://doi.org/10.1002/iroh.19880730406

65. Ishaq, M., & Kaul, V. (1988a). Distribution of minerals in a Himalayan lake. Tropical Ecology, 29, 41–49
66. Boyd, Claude. (2020). Total Hardness. 10.1007/978-3-030-23335-8_10.
67. Kaul, V., Trisal, C. L., & Handoo, J. K. (1978). Distribution and production of macrophytes in some water bodies of Kashmir.
68. Richards, F. A., Cline, J. D., Broenkow, W. W., & Atkinson, L. P. (1965). Some consequences of the decomposition of organic matter in Lake Nitinat, An Anoxic Fjord. Limnology and Oceanography, 10, R185–R201. https://doi.org/10.4319/lo.1965.10.suppl2.r185
69. Mustapha, M. K., & Omotoso, J. S. (2008). An assessment of the physico–chemical properties of Moro lake. African Journal of Applied Zoology and Environmental Biology, 7, 73–77. https://doi.org/10.4314/ajazeb.v7i1.41151
70. Maruthi, Y., Avasn, S, Rao, M.V., Krishna, R & Rao, S., 2002, Pollution status of river Sarada at Anakapalli, Andhra Pradesh - Indian Journal of Environment and Eco Planning, Vol, 3(1), pp. 45-48.
71. Das, A.C., Baruah, B.K., Baruah, D & Gupta, S.S., 2003, Study on wet lands of Guwahati city- 2. Water quality of rivers and rains, Pollution research, Vol, 22(1), pp. 117-119.
72. Enex. (1978). Study of the pollution of Dal Lake, Srinagar, Kashmir, India. A report prepared for the Commonwealth Fund for Technical Cooperation by Enex of New Zealand Inc.
73. Rabalais, N. N. (2002). Nitrogen in aquatic ecosystems. In: Ambio. Royal Swedish Academy of Sciences (pp. 102–112)
74. Schindler, D. W., Carpenter, S. R., Chapra, S. C., Hecky, R. E., & Orihel, D. M. (2016). Reducing phosphorus to curb lake eutrophication is a success. Environmental Science and Technology, 50, 8923–8929. https://doi.org/10.1021/acs.est.6b02204
75. Azmat, Seema & Sharma, Nitish & Firdous, Juhi. (2021). Latest Trends in Physico-Chemical Parameters of Dal Lake. Engineering. 12. 34-41. 10.34218/IJARET.12.3.2021.004.
76. Adimalla, N., & Venkatayogi, S. (2018). Geochemical characterization and evaluation of groundwater suitability for domestic and agricultural utility in semi-arid region of Basara, Telangana State. South India Applied Water Science, 8, 44. https://doi.org/10.1007/s13201-018-0682-1
77. Edokpayi, J. N., Odiyo, J. O., & Durowoju, O. S. (2017). Impact of wastewater on surface water quality in developing countries: A case study of South Africa. In: Water Quality. InTech
78. Dar, S. A., Bhat, S. U., Rashid, I., & Dar, S. A. (2020). Current status of wetlands in Srinagar City: Threats, management strategies, and future perspectives. Frontiers in Environmental Science, 7, 199
79. Sarshar Hameed Pushoo (2023). STATISTICAL REVIEW ON CHANGE IN WATER QUALITIES OF DAL LAKE. Statistical Review On Change In Water Qualities Of Dal Lake. Eur. Chem. Bull. 2023, 12(Special Issue 5), 4561 – 4568
80. M. Bhat,& M. Ali,Physico-Chemical Characteristics of Bod Dal Basin of Dal Lake, Kashmir, India, Journal Of Industrial Pollution Control,

ISSN (0970-2083)(2013).

81. S. Parvez, & S. Bhat, Searching For Water Quality Improvement of Dal Lake, Srinagar, Kashmir, Journal of Himalayan Ecol. Sustain. Development, 9(2014)
82. J. Bhat, & Z. A. Dar, Evaluation of Water Quality For Determining The Pollution Status of Dal Lake in Kashmir Himalaya. International Journal of Applied Research, 1, 10, 631- 634(2015)
83. M. A.Wani,A. Dutta, & WU. J. Wani, Analyzing Physico-Chemical Characteristics of Dal Lake Waters of Kashmir.,Global Journal of Engineering Science and Researches,2, 3(2015)
84. Y. H.Wani, M.Jatayan, S. Kumar& S. Ahmad, Assessment of Water Quality of Dal Lake, Srinagar by Using Water Quality Indices, IOSR Journal of Environmental Science, Toxicology And Food Technology (IOSRJESTFT), 10, 7, 95-101 (2016).
85. M. N. Dar, et al., Water Quality Assessments of Dal Lake, Jammu & Kashmir, International Journal of Scientific & Engineering Research, 8, 12, 328-337(2017)
86. U. Qayoom & A. Tanveer, Assessment of Groundwater Quality Along The Periphery of Dal Lake, International Journal of Advance Research in Science & Engineering, 7, 4), 2084-2096 (2018)
87. I. Gull, A. Abubakr, M. H. Balkhi, T. H. Shah, B. A.Bhat, F. A.Bhat & H. Qadri, Changes in Physico-Chemical Parameters at Different Sites of Dal Lake, Kashmir, The Pharma Innovation Journal, 10, 12, 281-288 (2021)
88. I.Rashid, S. Singla & R. Rathor, Exploration Into The Limnology of Dal Lake, Srinagar, Jammu And Kashmir, International Journal of Innovative Research in Technology, 9, 1(2022)
89. S. K. Bona & F. A. Lone, Seasonal Variation of The Water Quality of Dal Lake and its Tributaries in Srinagar City, Kashmir Valley, India. Journal of Environmental Chemistry And Ecotoxicology., ISSN: 2141-226(2023)
90. Wurts, William & Durborow, Robert. (1992). Interactions of pH, Carbon Dioxide, Alkalinity and Hardness in Fish Ponds. Southern Regional Aquaculture Center Publication. 464.
91. Mushtaq, B., Raina, R., Yaseen, T., Wanganeo, A., & Yousuf, A. R. (2013). Variations in the physico-chemical properties of Dal Lake, Srinagar, Kashmir. African Journal of Environmental Science and Technology, 7, 624–633. https://doi.org/10.5897/AJEST2013.1504
92. Rohini, A. (2016). A brief overview on conservation of lakes in India. CVR Journal of Science and Technology, 11, 106–110
93. Rather, I. A., & Dar, A. Q. (2020b). Assessing the impact of land use and land cover dynamics on water quality of Dal Lake, NW Himalaya. India. Applied Water Science, 10, 3. https://doi.org/10.1007/s13201-020-01300-5
94. Sultan, I., Ali, A., Gogry, F. A., Rather, I. A., Sabir, J. S. M., & Haq, Q. M. R. (2020). Bacterial isolates harboring antibiotics and heavy-metal resistance genes co-existing with mobile genetic elements in natural aquatic water bodies. Saudi Journal of Biology Science, 27, 2660–2668. https://doi.org/10.1016/j.sjbs.2020.06.002
95. Gulzar, B., Balkhi, M. H., Abubakr, A., Bhat, F., Asimi, A. O., & Bhat, B. A. (2020). Distributional pattern of algal/ plankton groups in relation with water quality of Himalayan Dal Lake, Kashmir,

India. Journal of Pharmacognosy and Phytochemistry, 9, 736–740
96. Wato, T., Amare, M., Bonga, E.,Demand, B. B. O., & Coalition, B. B. R. (2020). The Agricultural Water Pollution andIts Minimization Strategies–A Review
97. Ighalo, J. O., Adeniyi, A. G., Adeniran, J. A., & Ogunniyi, S. (2020). A systematic literatureanalysis of the nature and regional distribution of water pollution sources inNigeria. Journal of Cleaner Production, 124566.
98. Håkanson, L. (1999). Water pollution. Backhuys Publ, Leiden
99. Rosenquist, L. E. D. (2005). A psychosocial analysis of the human-sanitation nexus. Journalof Environmental psychology, 25(3), 335-346
100. Hussey, K., & Pittock, J. (2012). The energy–water nexus: Managing the links betweenenergy and water for a sustainable future. Ecology and Society, 17(1).
101. Evaluation of Operation and Maintenance of Sewage Treatment Plants in India (2007). Central Pollution Board, Ministry of Environment and Forests. Available from http//: www.en.wikipedia.org/water pollution. Retrieved on 15-09-2013.
102. WHO (2011). Guidelines for Drinking Water Quality.Vol. 1 & II recommendations, 4th ed. Available from http//: www.who.int/../en/. Accessed on 28-11-2013
103. Akpofure EA, Efere ML, and Ayawei P (2000): The Adverse Effects of Crude Oil Spills in the Niger Delta. Urhobo Historical Society Journal; 10: 10-14.
104. Cook JL, Baumann P, Jackman JA, and Stevenson D. "Pesticides Characteristics that Affect Water Quality". Available From http://insects.tamu.edu/extension/bulletins/water/water_01.html. Retrieved on 20-12-2014
105. Agrawal A, Pandey RS, and Sharma B (2010). Water Pollution with Special Reference to Pesticide Contamination in India. Journal of Water Resource and Protection; 2 (5): 1-17
106. Saleem, M., Jeelani, G., & Shah, R. A. (2015). Hydrogeochemistry of Dal Lake and thepotential for present, future management by using facies, ionic ratios, and statisticalanalysis. Environmental earth sciences, 74(4), 3301-3313.
107. Fritts, E. I. (2007). Wildlife and people at risk: a plan to keep rats out of Alaska. AlaskaDepartment of Fish and Game, Juneau, AK.
108. Das Sharma, S. (2019). Risk assessment and mitigation measures on the heavy metal pollutedwater and sediment of the Kolleru Lake in Andhra Pradesh, India. Pollution, 5(1), 161-178.
109. Frank R. Spellman, 2014. Water and Wastewater Treatment Operations. CRC Press Books.
110. Bona, Solomon. (2023). Environmental Pollution. Academia Open.
111. Mudasir Ahmad Wani, et al, (2014). Towards Conservation of World-Famous Dal Lake – A Need of Hour. International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, p-ISSN: 2395-0072, Volume: 01 Issue: 01
112. Chashoo, H. F., Abubakr, A., Balkhi, M. H., Shah, T. H., Malik, R., Bhat, B. A., & Gul, S. (2020). Impact of sewage treatment plant efuent on water quality of Dal Lake, Kashmir. India. International journal of chemical studies, 8, 1915–1921.
113. Ruhela, M., Wani, A. A., & Ahamad,

F. (2020). Efciency of sequential batch reactor (SBR) based sewage treatment plant and its discharge impact on Dal Lake, Jammu & Kashmir, India. Archive of Agriculture Environmental Science, 5, 517– 524. https://doi.org/10.26832/24566632.2020.0504013

114. Badar B., & Romshoo, S. A. (2008). Assessing the pollution load of dal lake using geospatial tools. Proc Taal 2007 12th World Lake Conference, 668–679
115. Nengroo, Z. A., Bhat, M. S., & Kuchay, N. A. (2017). Measuring urban sprawl of Srinagar city, Jammu and Kashmir, India. Journal of Urban Management, 6, 45–55. https://doi.org/10.1016/j.jum.2017.08.001
116. Qayoom, U., Ullah Bhat, S., & Ahmad, I. (2021). Efciency evaluation of sewage treatment technologies: Implications on aquatic ecosystem health. Journal of Water and Health, 19, 29–46. https://doi.org/10.2166/WH.2020.115
117. AHEC. (2000). Conservation and management of Dal-Nigeen lake. Detailed Project Report submitted to Ministry of Environment and Forests, GOI and Government of Jammu and Kashmir, 1–5
118. Kumar, P., Mahajan, A. K., & Kumar, P. (2020). Determining limiting factors influencing fsh kills at Rewalsar Lake: A case study with reference to Dal Lake (Mcleodganj), western Himalaya, India. Arabian Journal of Geosciences, 13, 1–21. https://doi.org/10.1007/s12517-020-05792-y
119. Rehman, M., Yousuf, A. R., Balkhi, M. H., Rather, M. I., Shahi, N., Meraj, M., & Hassan, K. (2016). Dredging induced changes in zooplankton community and water quality in Dal Lake, Kashmir, India. African Journal of Environment and Science Technology, 10, 141–149. https://doi.org/10.5897/ajest2016.2096
120. Mir, B. A., Shah, B. M., & Shah, F. A. (2018). Some model studies on reinforced dredged soil for sustainable environment (pp. 1697–1700). Springer.
121. Rather, J. A. (2012). Evaluation of concordance between environment and Economy: A resource inventory of Dal Lake. International Journal of Physical Social Science, 2, 483–507.
122. Mir, B. A. (2017). On integrated testing and performance assessment of dredged solid waste from Dal Lake for sustainable environment in Srinagar. American Journal of Civil Environment Engineering, 2, 1–7.
123. Chowdhury, C. L. (2018). Greater Srinagar and Dal Lake integrated environmental project proposal — A review. In: Geomechanics and water engineering in environmental management (pp.233–266). Routledge.
124. Mukhtar, F., & Chisti, H. (2013). Assessment of water quality by evaluating the pollution potential of Hazratbal basin of Dal lake, Kashmir, India. Australian Journal of Basic and Applied Sciences, 7, 1–2.