FIELD STUDY REPORT

Submitted to the University of Kerala in partial fulfillment of award of the Degree of Master of Science in Zoology

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CONTENTS

INTRODUCTION

First time in the entire cultural history, man has faced one of the most horrible ecological crises – the problem of pollution of his environment which sometimes in the past was pure, virgin, undisturbed and basically quite hospitable for him. Pollution is an undesirable change in the physical, chemical or biological characteristics of our air, land and water that may or will harmfully affect human life or that of desirable species, our industrial processes, living conditions and cultural aspects (Odum, 1971).

Environmental pollution is a global problem and is common to both developed as well as developing countries, which attracts the attention of human beings for its severe long-term consequences. The decline in environmental quality as a consequence of pollution is evidenced by loss of vegetation, biological diversity, excessive amounts of harmful chemicals in the ambient atmosphere and in food grains, and growing risks of environmental accidents and threats to life support systems. Pollution is viewed from different angles by different people but is commonly agreed to be the outcome of urban-industrial and technological revolution and rapacious and speedy exploitation of natural resources, increased rate of exchange of matter and energy, and everincreasing industrial wastes, urban effluents, and consumer goods.

Holdgate (1979) defined environmental pollution as the introduction by man, into the environment, of substances or energy liable to cause interference with legitimate uses of environment.

Singh (1991) has defined pollution in a very simple manner, i.e., "Disequilibrium condition from equilibrium condition in any system." This definition may be applied to all types of pollution ranging from physical to economic, political, social, and religious. Over the past couple of decades, various sources of pollution were identified that altered the composition of water, air, and soil of the environment. Some authors associate the human population explosion with the pollution problem. They point out that with more people, there is more sewage, more solid wastes, more fuel being burned, more fertilizers and insecticides being used to produce more food for hungry mouths. But there are certain writers who have pointed out that in under developed countries, pollution is not the severe problem as it is in technologically developed countries the population may be very dense. They feel that it is the wasteful aspects of our technology which strive always to produce more convenient products (disposable items) which pollutes the environment. This pollution mainly

occurs, when short term gains are made at the cost of long term ecological benefits for humanity. No natural phenomenon has led to greater ecological changes that have been made by mankind. During the last few decades ,we have contaminated our air, water, and land on which life itself depends with a variety of waste products. Pollutants include solid, liquid, or gaseous substances present in greater than natural abundance produced due to human activities which have detrimental effect on our environment. There are different types of air pollutions are there based on the pollutants. It includes water pollution, thermal pollution, air pollution noise pollution etc.

Kollam district is situated on the south-west coast of Kerala. The district is bound on the north by Alappuzha, north-east by Pathanamthitta, east by Thirunelveli district of Tamilnadu, on the south by Thiruvananthapuram district and on the west by Arabian Sea. The area of the district is 2,492 sq.kms. In area, the district ranks 7th in the state. The district is lying between 8°53 N, 76°36E latitude and 8.88°N,76.60°E longitudes. The two rivers Kallada and Ithikkara flows through the district. The Sasthamkotta lake, one of the major fresh water lake in the state is in Kollam district. Kollam (Malayalam:) (known to the Portuguese as Quilon, pronounced koy-lon) is a city and a municipal corporation in Kollam district in the Indian state of Kerala. It lies 71 Kilometres north of the state capital Thiruvanathapuram(Trivandrum). It is also the headquarters of the Kollam District, one among the 14 districts in the state of Kerala. At present the pollution status of this city has been increasing day by day due to the uncontrolled human activities.

Water is one of the most important constituent of the life support system which is essential for the survival of all life forms and on the other it helps in the movement, circulation and cycling of nutrients in the biosphere. It is important for the power generation, navigation, irrigation of crops and so on. But now, population explosion, rapid industrialization and unplanned urbanization are releasing a lot of waste into water bodies thereby degrading the quality of water. Thus water pollution is the deterioration of physical, chemical and biological characteristics of water through natural and anthropogenic activities to such an extent that it becomes harmful to human beings, plants and animal communities. Water pollution is a global problem affecting both developed and developing countries. Human activities related with water pollution comprises of mining, agriculture, stockbreeding, fisheries, urban human activities, various industries such as manufacturing industries, domestic sewage etc.

Effluents from KMML (Kerala Metals and Minerals Ltd), a public sector unit based at Chavara in Kollam, are polluting water sources, degrading the environment, and posing a public health hazard. The pollution has affected the life and livelihoods of the people in the surroundings areas of KMML and are suffering from bronchitis, asthma and skin ailments. The incidence of cancer is very high. The plant manufacturing titanium dioxide was responsible for the deterioration

in the quality of groundwater sources. The paper titled "Impact of Rare Earth Mining and processing on oil and water Environment at Chavara, Kollam, Kerala" : A case study published in the journal Procedia Earth and Planetary Science, describes that: Discharge from the industry had resulted in the lowering of pH of water and soil , leading to loss of vegetation , and water and soil quality deterioration. Soil and water were heavily polluted with iron and chlorine. There was an increased concentration of trace metals like copper, nickel, zinc, lead, vanadium, chromium, strontium, selenium, cobalt, which also posed the threat of increasing the heavy metal loading in the surrounding subsoil and surface water sources. The processes increased dust that included radioactive elements, which posed a health risk to those living nearby. Calculated pollution indices and water quality indices confirmed the very high water and soil pollution in the area. The paper argues that these potential threats of environmental deterioration continue to be ignored due to the difficulty associated with regulating the industry that produces resources of high strategic importance. Crops were found destroyed by concentrated hydrochloric acid and other pollutants present in the environment. The factory has seven tube wells with depth ranging from 100m to 200 m which has an average groundwater withdrawal of 10 lakh litre a day. The waste water discharged by the company was found accumulating in the environment and polluting natural water bodies before reaching the sea. The area to the north of the factory was filled with pools of brownish yellow, pungent smelling water, highly acidic and reactive. The colour change was noticed in the wells and ponds also. The company's claim that the impact of its effluents was limited to less than 100 meters of the discharge point, after which the acidity was neutralized by the sea. However it was opposed, as several studies points out that about 15sq.km.area was badly affected and that the pollution was slowly spreading in all directions.

The coastline between Chavara and Alappad in Kollam district of Kerala, has a decadeslong story of people's battle for survival against mining companies. On a journey through this coastal belt, one can spot abandoned houses, temples, schools and many more buildings where people once lived. Red coloured ponds and dried up mangrove forests are another painful sight on this coastline. This stretch in Kerala is where the extensive mineral beach sand mining has been happening since the 1960s. The abandoned buildings are the remains of people's failed agitations and indefinite strikes. One by one the villages in the area are vanishing from the map of Kerala. A village named Panmana has turned in to a heap of sand and an abandoned temple stands around which thousands of fishermen once lived. In Alappad Panchayat, activists estimate that more than 6,000 fishermen families have vacated over the years due to beach erosion, drinking water scarcity and lack of fish availability. Sooner or later the panchayat has been turned in to a sand bund.

Kovilthottam, another village on the coastline, also has only 50 families left. “In 2010 almost all indigenous communities were evicted from Kovilthottam region in Chavara, promising that they will be allowed to rehabilitate back in their own land after completing the mining within three years. Even eight years after those evictions, no rehabilitation has occurred, more than 500 families are homeless. The remaining families in this 23 kilometres stretch of coastal region (Kollam Neendakara to Kayamkulam) are under the threat of eviction; for the last few years, they have been expecting a massive coastal erosion that can engulf their villages. Most of the people have been forced to leave their houses, even without any compensation from the authorities or the mining companies and the remaining people in Alappad and nearby areas have been on an indefinite strike against mining companies planning to extend their projects.

Mineral sand mining in Kollam is badly effecting the environment and atmosphere. The presence of the minerals ilmenite, rutile, zircon, monazite, leucoxene (brown ilmenite), sillimanite and garnet in coastal sand dunes of Kollam was discovered in 1920s. Two public sector companies, Indian Rare Earth (IRE) which comes under central government and Kerala Minerals and Metals Limited (KMML), a company under the state government have been mining since 1968. Though by 1995 many foreign companies had tried mining in the coastal area, continuous protest from the public and activists forced them to drop the projects IRE and KMML still continue to do extensive mining in the area irrespective of people’s protest. Since the companies have got clearances from respective departments of state government as well favourable orders from the High Court of Kerala, the opposition voices are silenced. There is no data on people who were evicted without any compensation for their loss and no enquiry about polluted drinking water sources of this coastal belt. Though activists quote the numbers of families vacated from the region, there is no official data on it.

In Chittoor region near Chavara there are open ponds which have been used by companies for dumping chemical waste. It has been years since the residents there stopped using these drinking water sources. After repeated agitations the companies started providing drinking water to the residents in Chavara region, but not regularly. Loss of drinking water, fish stock depletion and erosion are other problems associated with this.

Tremendous increase in population caused significant increase for the need of natural resources. The direct consequences are for quantity and quality of the available freshwater to human consumption. Natural water bodies are able to serve many uses, including the transport and assimilation of wastes. But as water bodies integrate these wastes, their quality changes. If the quality drops to the extent that other useful uses are adversely affected, the assimilative abilities of

those water bodies have been increased with respect to those affected uses. The most human needs for water are for drinking, cooking and personal sanitation. To meet these needs, the quality of the water used must pose no risk to human health.

One such pollution effected water body is the Ashtamudi lake. The Ashtamudi Lake in the kollam district lies in between 76.53°and 76.63° longitude and 8.93° and 8.83° latitude. It is a palmshaped extensive water body with eight prominent arms, adjoining the Kollam town. This extensive estuarine system has a length of 16 km with a maximum width of 14 km and maximum depth up to

6.4m covering an area of 64.2 km^2. It is surrounded by lush green trees and swaying coconut palms. This 16 km long lake is the second largest lake in Kerala, which has found its way into the sea through the Neendakara estuary. This place is so beautiful that tourists from different parts of the country and abroad, visit this natural paradise to catch a glimpse of one of many splendours of Ashtamudi. A lot of tourists come here to experience boat ride, which gives a glimpse of village life, natural habitat, and abundant flora. This lake is known for its panoramic beauty and eight channels that connects to one lake. It is because of its eight 'arms' or channels, that the lake is named Ashtamudi.

The eight different branches of Ashtamudi each have different names. They are Thevally Lake, Kandachira Lake, Kureepuzha Lake, Thekkumbagham Lake, Kallada Lake, Perumon Lake, Kumbalathu Lake and Kanjirottu Lake. The lake is laid with Chinese fishing nets to give it a different look. The banks of the lake are laden with greenery and bushes, which makes it a beautiful sight for sore eyes. Motorboats that range from 2 seaters to 14 seaters are available depending on the person's requirement.. The Ashtamudi Lake has been designated as a Ramsar Site (No.1204) in November 2002 and is also a major tourist place.

The Backwater stretch of Ashtamudi is one of Kerala's unrevealed secret. Ashtamudi Lake is the second largest in the state of Kerala, situated in the Kollam district. Ashtamudi Lake is also called the gateway to the backwaters of Kerala. About thirty percent of the historic Kollam town is encompassed by the placid Ashtamudi Lake. Kollam has been one of the leading cities in olden times. It was a leading trade capital of the old world from the era of the Phoenicians and Ancient Rome. The backwaters of Ashtamudi are a complex labyrinth. It is the second largest and deepest wetland ecosystem. The name 'Ashtamudi' is adapted from the topography of the lake. 'Ashta' means eight and 'mudi' means coned. The beautiful lake gets its name Ashtamudi, because of its 8 arms or channels. The scenicwater body is the gateway to the backwaters. The labyrinthine network comprise myriad brackish lagoons, lakes, canals, rivers and inlets. The serene backwater stretch of

Ashtamudi Lake is embraced by clusters of palm and coconut trees. Typical quaint villages of Kerala dot the banks of the lake. The blessed ambiance is an inspiring muse. Writers, painters and observers are left in awe of the beauty. The nurturing waters of Ashtamudi are the source of livelihood for the villagers. Fishing and coconut husking are two of the popular here. The backwaters of Ashtamudi are inhabited by innumerable species of life. It includes different varieties of mangroves, supports around 43-marshy mangrove species, more than 57 species of avifauna and 40 species of wetlanddependent birds97-species of fishes and some unique copepod species which are important sources of food. More than 20,000 waterfowl visit the lake annually. The count does not stop here; more than 26 species of butterflies have been identified. Nothing short of God's Own country describes the blessed region.

Now, the lake has become one of the worst victims of human avarice and disdain for environment. Its very existence is under threat now: the area has shrunk; it's being encroached upon, and being made a waste dumping yard. Its water has lost its quality. The lake, which once offered livelihood to thousands, has stopped being so. The lake that once spanned across an area of 61.40 sq. kilometres has now shrunk to 34 sq. kilometres, almost half its original size. The lake has lost 27 square kilometres hence new islets formed between Dalawapuram, Neendakara, and Kavanadu have contributed to the reduction in area of the lake, apart from the encroachment for accommodating the ever increasing population.

Ashtamudi lake has become a victim of urban pollution as the water body shares a major portion of its boundary with Kollam corporation. As per studies conducted in 2011, biological oxygen demand in the lake was one third of the standards set by the Central Pollution Control Board (CPCB) for water fit for outdoor bathing and the dissolved oxygen was as low as 1mg/L which is just one-sixth of the standards.

In 2002, when Ashtamudi Lake in Kerala was brought under the Ramsar convention, it was expected that this would stop the lake's deterioration. Usually, when a water body gets notified under this international treaty on wetland conservation, its preservation and protection is boosted. Ashtamudi, however, lost 27 square kilometres in the decade that followed. In 2002, the area of the lake was 61.4sq km. According to the Wetland (Conservation and Management) Rules, 2010, formulated by the Ministry of Environment, Forest and Climate Change, the water bodies listed under the Ramsar Convention are not to be polluted or encroached upon. In the case of Ashtamudi, various government bodies have also been polluting and encroaching upon the lake. The population of Kollam City is 361,440 and is likely to grow to up to 400,000 by 2031. The rapid growth of Kollam City due to establishment of new Goverenment offices and Industrial projects (Neendakara

Port and Titanium Complex projects) have inreased the pollution load on the Ashtamudi Lake. In 2001, the Kerala Tourism Development Corporation built a hotel right on the bank of the lake. It has also been discharging untreated sewage into the lake and afterwards it has turned black and stinks. In a similar case, the Kollam Corporation commissioned a biogas plant on the bank of the lake in 2007 with the help of the State Pollution Control Board. The plant operated for a short duration and pumped raw sewage into the lake. But in 2008, the board directed the corporation to shut it because the health of the lake had started to deteriorate.

The Ashtamudi lake is now posing threat to the health of residents of the city due to its high pollution levels. Untreated effluents from various hospitals and sewage from many establishments flow into it despite protests by environmental activists. There are many other reasons and causes are there for the pollution of Astamudi lake which includes garbage dumping, sand mining, water channels, water transport system, T.S canal, coir retting etc. According to a 2007 study by the University of Agriculture Science, Bangalore, the lake has an annual economy of over Rs 1,900 crore, with 87 per cent of it coming from fisheries. Around 3,000 fisher folk depend on the lake for their catch. The unimpeded tourism activities contribute significantly to pollution, which has accelerated water eutrophication, encroachment, reclamation, mining and biodiversity loss.

The main objective of this field visit is to find out the present status of Ashtamudi lake as a result of the anthroprogenic activities. To find out about what extend the lake is polluted the parameters like Temperature, Ph, Hardness, Transparency etc. have been recorded from 15 selected stations in the Ashtamudi Lake.

REVIEW OF LITERATURE

Hydrography of backwaters in Kerala was extensively carried out by various researchers and scientists. A preliminary study on the ecological status of Kayamkulam estuary was conducted by Mary John (1958).Investigations on cochin backwaters were carried out by Qasim and Gopinathan (1969); Sankaranarayanan and Qasim (1969); Haridas et al. (1973);Anirudhan et al. (1987); Balachandran (2001); Balachandran et al. (2006) and Madhu et al. (2010). The titanium dioxide industrial effluent discharge to a habitat leads to the reduction in pH Weichart, (1972).

Sarala Devi et al. (1979) studied the effect of industrial pollution on water quality parameters in Cochin backwaters. Madhupratap et al., (1979); Menon et al., (1979) and Haridas et al., (1980) studied the Travancore Titanium dioxide factory effluent on marine animals. A detailed investigation has not yet been conducted on the backwater system exposed to the effluent from titanium dioxide factory with a different processing mechanism (Chloride process). A preliminary study on the ecology and biodiversity of the Kayamkulam backwaters was conducted by Kuttyamma (1980) and Gopakumar (1991). Dharmaraj and Nair (1981) evaluated the nature of distribution of major inorganic nutrients in the Ashtamudi backwaters in relation to local environmental factors. Dharmaraj and Nair (1981) studied the distribution of inorganic nutrients in the Ashatamudi backwaters in relation to environmental factors. The problems are aggravated by shrinkage of the Cochin backwaters due to reclamations over the past decades (Gopalan et al., 1983). Abdul Azis and Nair (1986); Nair and Aziz (1988) and George Thomas (1995) have reviewed the ecology of Ashtamudi estuary.

Mallik and Suchindran (1984) studied the sedimentological aspects of Vembanadu backwater system. The heavy metal pollution in the sediments of Cochin estuarine system has been studied (Ouseph, 1987). Cochin backwaters, one of the largest tropical estuaries of India (256 km^2), are facing massive pollution hazards due to the release of untreated effluents from the industries and domestic sectors (CPCB, 1996 and Martin et al., 2008). Heavy metal pollution in Ashtamudi backwaters has been documented (Geetha, 1997).

D'Cruz (1998) conducted studieson the effect of KMML industrial effluent on the biota of Chavara, Panmana

Menon et al. (2000) and Greenpeace (2003) documented the presence of more than 240 industrial units operating in Eloor, Kalamasery industrial belt alone with an average release of about 2.6 million litres of untreated effluents per day into the adjoining backwaters.

The Kerala coast is endowed with 30 backwaters with extensive tract of perennial and temporary estuaries running parallel to the shoreline. Out of the 30 backwaters of the Kerala coast, seven are characteristically river mouth estuaries (Bijoy Nandan, 2004). The unprecedented and rapid industrialization have resulted in the release of a deluge of effluents, solid waste and liquid wastes into the aquatic realm (Radhika et al., 2004). Hatha et al. (2008) documented bacteriological contamination in Vembanadu and highlighted the associated public health threats to the adjoining population. Backwaters and rural estuaries in Kerala experience varying degrees of pollution. Vembanadu backwaters, the largest of its kind on the west coast of India is struggling in the midst of pollution. The most appalling ecological outcome is the disruption of the physical and biological continuity of the lake which led to the decline of flora and fauna (Duncan, 2009).

Impact of coconut husk retting on the water quality and biodiversity in the Kayamkulam backwaters has also been investigated (Somanathan, 2008). Anoop and Suryaprakash (2008) evaluated the option values and pollution threats of Ashtamudi backwaters. The predominant factors responsible for deterioration of the Ashtamudi backwatersare pollution and encroachment. The mushrooming of industries, tourism activities adjacent to the shores and basin without proper effluent and waste treatment facilities are the major ecological threats. Intensive coconut husk retting, oil and excreta release from house boats together with encroachment are the immediate threats. The impact of sea sand filling in the Paravur-Kappil backwaters, Southern Kerala have also been thoroughly investigated (Santhosh et al., 2009).

Babu et al. (2010) also reported the deterioration of the physicochemical quality of water in Ashtamudi backwaters. There exists lacuna of knowledge on the extent of pollution in the Vattakayal backwaters near to the industrial area.. The deterioration of water quality among wetlands (Vineetha et al., 2010), estuaries (Anilakumary, 2001), rivers (Sujitha et al., 2011) and well water (Shaji et al., 2009) in Kerala have been reported.

Meera and Nandan (2010) reported the diminishing water quality and productivity of Valanthakad backwaters in Kerala. The presence of acids, alkalis, suspended solids, fluorides, free ammonia, insecticides, dyes, trace metals and radioactive nuclei were well reported from Cochin backwaters (Kaladharan et al., 2011). Hence the present work has been taken up to study the pollution status of Ashtamudi lake .

MATERIALS AND METHODS

A . STUDY AREA

The Ashtamudi Lake in the Kollam district lies in between 76.53°and 76.63° longitude and 8.93° and 8.83° latitude. It is a palm-shaped extensive water body with eight prominent arms, adjoining the Kollam town. This extensive estuarine system has a length of 16 km with a maximum width of 14 km and maximum depth up to 6.4m covering an area of 64.2 km^2. It is surrounded by lush green trees and swaying coconut palms. This 16 km long lake is the second largest lake in Kerala, which has found its way into the sea through the Neendakara estuary. It is because of its eight 'arms' or channels, that the lake is named Ashtamudi. The eight different branches of Ashtamudi each have different names. They are Thevally Lake, Kandachira Lake, Kureepuzha Lake, Thekkumbagham Lake, Kallada Lake, Perumon Lake, Kumbalathu Lake and Kanjirottu Lake. The study was conducted on 8th October 2021.

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B. SAMPLING AND DATA COLLECTION

The samples were taken from 15 stations of Ashtamudi lake. The collections were made during the day time. Surface water samples were collected using clean bucket. Samples were stored and preserved as per APHA standards. Water samples were stored in pre- rinsed plastic bottles and analysis were done on the next day itself.

STATION 1 - KANDACHIRA LAKE

STATION 2 - THEVALLY LAKE

STATION 3 – KUREEPUZHA LAKE

STATION 10 – MONROETHURUTH

STATION 11 – MALAYILKADAVU

STATION 12 – CHERIKADAVU

STATION 13 – KAVANAD

STATION 14 – MAMMOTTYKADAVU

STATION 15 – ADVENTURE PARK

C. ANALYSIS

All analysis were conducted using standard analytical methods (APHA,1985).The water samples were analysed for certain parameters which includes pH, Temperature, Transparency dissolved oxygen, total hardness, calcium, magnesium,

(i) Temperature

Temperature is a crucial water quality parameter which regulates the maximum dissolved oxygen concentration. Temperature can be measured using a glass thermometer. For this immerse the thermometer in the sample water until the liquid column in the thermometer stops moving and then note down the readings.

(ii) Transparency

Transparency is a water quality characteristic of water bodies which varies with the combined effects of colour and turbidity. The apparatus used for transparency measurement is called as Secchi disc. The disc is made of rigid plastic or metal It may be 20 to 30cm or even larger in diameter and is usually painted with white and black quadrants. The disc is suspended on a light rope or chain so that it remains horizontal when it is lowered into the water. The suspended rope is graduated at intervals of 0.1 and 1 m from the level of the disc itself. In order to measure the transparency, lower the Secchi disc, where possible, through a shaded area of water surface. As the disc is lowered, note the depth at which it just disappears from view. Lower the disc a little further, then raise it and note

the depth at which it reappears. The average of the two depth readings is reported as the Secchi disc transparency.

(iii) pH

The pH of the samples was measured using pH paper which is a chemical detector for the hydronium ion or hydrogen ion. Dip the end of the pH strip into the sample that needs to be tested. After a couple of seconds, remove the paper and compare the colour of the PH strip to the colour chart provided with the PH paper kit.

(iv) Dissolved oxygen

The Winkler method is used to determine the dissolved oxygen in the water sample. A sample bottle is completely filled with water in such a way that no air is left to skew the results. The dissolved oxygen in the sample is then fixed by adding a series of reagents (2ml each of Manganese sulfate, alkali iodide azide, concentrated sulphuric acid, starch solution) which forms an acid compound which when titrated against a neutralizing compound, sodium thiosulphate results in colour change. The point of colour change is called the end point., which coincides with the dissolved oxygen concentration in the sample.

(v) Calcium

To determine the amount of calcium present, add 2 ml of NaOH to 50ml of the sample. Then add 100mg to 200mg murexide indicator, which will lead to the formation of pink colour. Titrate this against the EDTA solution. Colour change from pink to purple is the end point.

(vi) Hardness

Hardness is generally caused by the calcium and magnesium ions present in the water. To determine the hardness add 1ml of buffer solution to 50ml sample taken in the conical flask. To this add 100 200 mg of Erichrome black T indicator. Then the solution will turns to wine red. Titrate this against EDTA solution. The colour change from wine red to blue is the end point.

RESULT AND DISCUSSION

The various parameters of Ashtamudi lake studied are PH, Temperature, Transparency, Dissolved oxygen, Depth, Calcium, hardness and Total hardness,

PHYSICO CHEMICAL PARAMETERS

TEMPERATURE

Temperature is a crucial water quality parameter which regulates the maximum dissolved oxygen concentration. In the present study, atmospheric temperature and also the temperature of both, bottom and surface samples are noted down. The atmospheric temperature is very high at S1 (Kandachira lake) (32 degree Celsius) and it was found to be comparatively low at S12 (Cherikadavu) (27.5 degree Celsius).Analysis showed that, the temperature noted down is comparatively high in case of the surface sample of the station S15(Adventure park). A Temperature of about 29 degree Celsius has been noted down on analysing the bottom sample of station S13,which is the lowest temperature experienced among all the stations.

DEPTH

Depth of Ashtamudi Lake showed marked variations from one station to another .Depth at stations S6 and S11 (Perungalam and Malayilkadavu) was observed to be the maximum, which is about 15 feet. The station S4 (Sambranikodi) is the area which is having the minimum depth of about 6 feet. The depth of all other stations ranges in between 7 and 13 feet.

TRANSPARANCY

Transparency is a water quality characteristics of water bodies which varies with the combined effects of colour and turbidity. The secchi disc visibility showed wide variations at different stations of the Ashtamudi Lake. Transparency value is found to be relatively high (133cm) at S10 (Monroethuruth) and the minimum transparency value (43.5cm) has been noted down at S15 (Adventure park).

pH pH is one of important parameter for water quality which indicates hydrogen ion concentration in water. pH is a scale of intensity of acidity or alkalinity and measures the concentration hydrogen ions in water. pH of natural water varies around seven (6 to 7). A lower pH value below 4 produces sour taste and high value, above 8.5 a bitter taste. Present results reveal with the pH ranges between 5 and 7. The lowest PH value is noted down from the analysis of the bottom sample of S7 (Perumon) and the surface sample analysis of S11 (Malayilkadavu). Lowering of pH might be due to stagnation, decay of vegetable matters, discharge of domestic sewage and increase of carbon dioxide. Station S1 (Kandachira lake) had shown the highest pH among all the stations. The PH of the sediment taken from various other stations also ranges in between 6 and 7.

DISSOLVED OXYGEN

Dissolved oxygen (DO) levels in the natural and waste water depend on the physical, chemical and biochemical activities of water body. Dissolved oxygen refers to the level of free, non-compound oxygen present in water or other liquids. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. A dissolved oxygen level that is too high or too low can harm aquatic life and affect water quality. The dissolved oxygen value of both surface and bottom samples of S15 (5.55mg/L) is the highest when compared to all other stations. The lowest dissolved oxygen value (0.88mg/l) is measured in the bottom sample of the station S1 (Kandachira lake). But 4.44 mg/l is the value of dissolved oxygen ,noted down in the case of surface sample of the same station. Low DO levels are often the result of organic pollution .The dissolved oxygen value of the surface sample of the station S10 (Monrothuruth) is also comparatively less when compared to all other stations, whose DO values are in between 2.22 and 4.44. No samples which are taken from different sites of the Ashtmudi Lake showed a DO value greater than 6mg/L, which is the minimum concentration required for a contamination free water body. Therefore it is evident that the Ashtamudi Lake is highly polluted.

CALCIUM

Many indicators such as ammonium purpurate, Carbon etc form a complex with only calcium but not with Magnesium at higher pH. Being an important contributor to hardness in water it reduces the utility of water for domestic use .On Analysing the bottom sample of station S2 (Thevally lake)

,it is revealed that the calcium content is very high (368.736 mg/L) here .S11(Malayilkadavu) is the station whose surface sample analysis had shown a minimum calcium content (96.192mg/L).The permissible limit of calcium content is only 75mg/L as per the drinking water standards. But the results have shown that the calcium content present in the Ashtamudi lake is enormously high .Even the S11 (Malayilkadavu) which has the minimum calcium content (96.192mg/L) is also above the permissible limit .

TOTAL HARDNESS

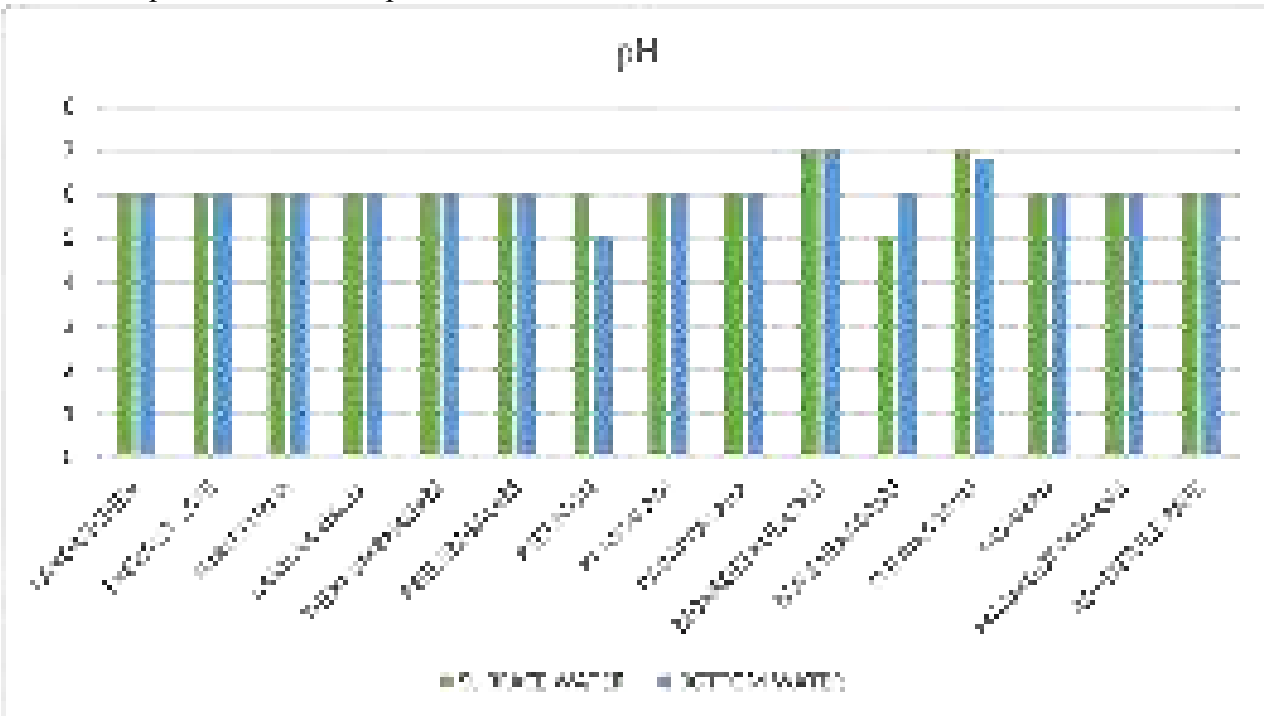
Total hardness of water is the sum of concentration of alkaline earth metal cations present in it. Hardness is caused by carbonates and bicarbonates and is important for aquatic organisms. Calcium and magnesium are the principal cations imparting hardness. Hardness of water prevents lather formation with soap and therefore hard water is not suitable for bathing and washing. The total hardness value had showed marked variations with respect to different stations of the Ashtamudi Lake. Total hardness of the surface and bottom samples of station S6 (Perungalam) is 6930 mg/L and 7300mg/L respectively which is the highest value obtained among all the stations. The lowest total hardness value is noted down on analysing the surface and bottom sample of the station S1 (Thevally) which is 1240mg/L and 2260mg/L respectively. In this study the hardness values ranged from 1240mg/L to 7300mg/L.

Table 1 : Variations of Parameters in 15 different stations of Ashtamudi lake

Sl. No.	Station		Parameters								
			Atmospheric Temperature (°C)	Temperature (°C)	Depth (Feet)	pH (Water)	Transparency (cm)	Hardness (mg/L CaCO3)	Calcium Hardness (mg/L CaCO3)	Dissolved O2 (mg/L)	pH (Sediment)
1	[illegible]	SURFACE	37	31	11	6	105	1240	256.512	0.88	[illegible]
		BOTTOM		31		6		2200	272.704	4.44	
2	THEVALLY LAKE	SURFACE	30	31	8	6	133	3120	352.704	2.22	5
		BOTTOM		31		6		5360	368.704	3.33	
3	KUNNEPUZHA LAKE	SURFACE	30	31	7	6	118.5	2420	344.288	2.22	[illegible]
		BOTTOM		31		6		5560	360.72	2.22	
4	SANKARANKULAM	SURFACE	30	30	6	6	110.5	[illegible]	[illegible]	2.22	5
		BOTTOM		29.5		6		4160	352.704	2.22	
5	THOOKKUMOOLAGAM	SURFACE	30	31	7	6	102	3700	368.576	1.33	[illegible]
		BOTTOM		31		6		2820	312.624	3.33	
6	[illegible]	SURFACE	29	31	15	6	177.5	5480	504.608	1.33	7
		BOTTOM		30		6		3700	328.576	1.33	
7	[illegible]	SURFACE	29	31	13	6	140	5700	296.592	3.37	[illegible]
		BOTTOM		30		5		6820	312.624	3.37	
8	[illegible]	SURFACE	29	31	17	6	95	6360	248.496	3.37	nil
		BOTTOM		31		6		5700	272.704	3.37	
9	[illegible]	SURFACE	30	32.5	6	6	79	2300	224.448	2.22	4
		BOTTOM		31.5		6		1100	240.48	3.33	
10	[illegible]	SURFACE	28.5	32	13	7	133	3440	104.208	1.33	5
		BOTTOM		32		7		2520	128.256	2.22	
11	[illegible]	SURFACE	29.5	32.5	15	5	111.5	1520	95.102	0.88	[illegible]
		BOTTOM		32		6		3320	130.24	4.44	
12	[illegible]	SURFACE	27.5	32	7	7	103.5	7100	216.432	2.22	[illegible]
		BOTTOM		32		6.4		3520	240.48	3.37	
13	[illegible]	SURFACE	29	30.5	8	6	95	3520	304.608	1.33	nil
		BOTTOM		29		6		3700	304.576	1.33	
14	[illegible]	SURFACE	30	31	7	6	85	3120	296.512	3.37	nil
		BOTTOM		30		6		2700	288.576	2.22	
15	[illegible]	SURFACE	31	31	8	6	48.5	3480	368.176	1.95	nil
		BOTTOM		33.5		6		5620	312.624	3.56	

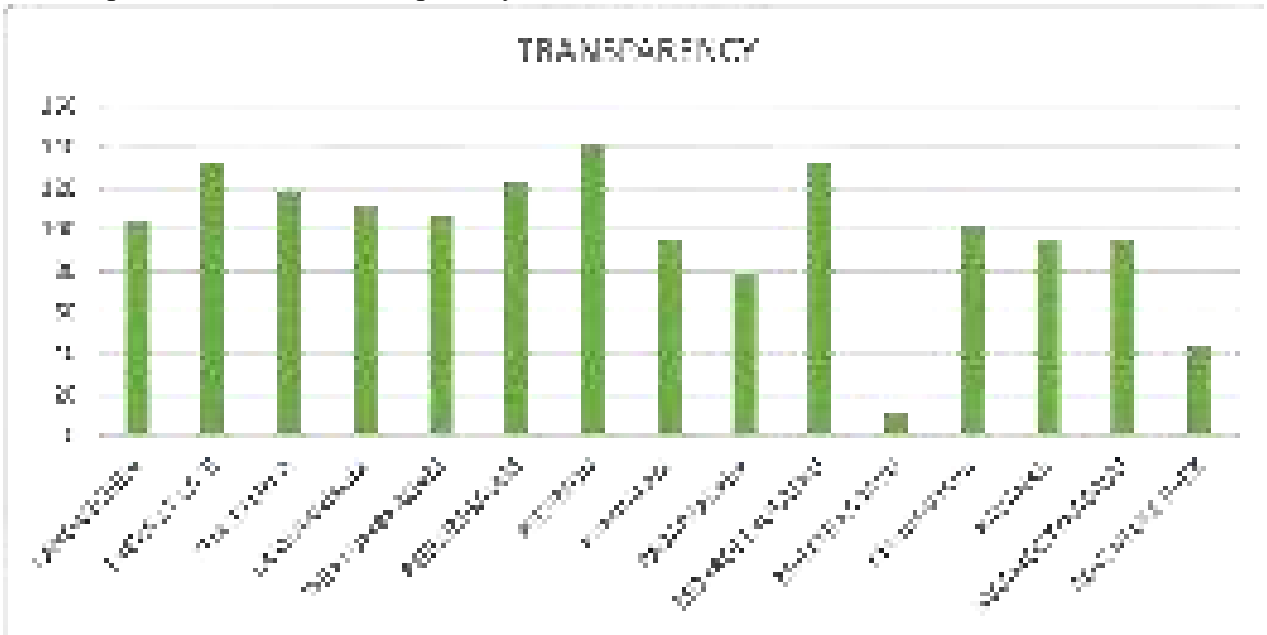
1) pH

Graph 1: Variation of pH in different stations of Astamudi lake



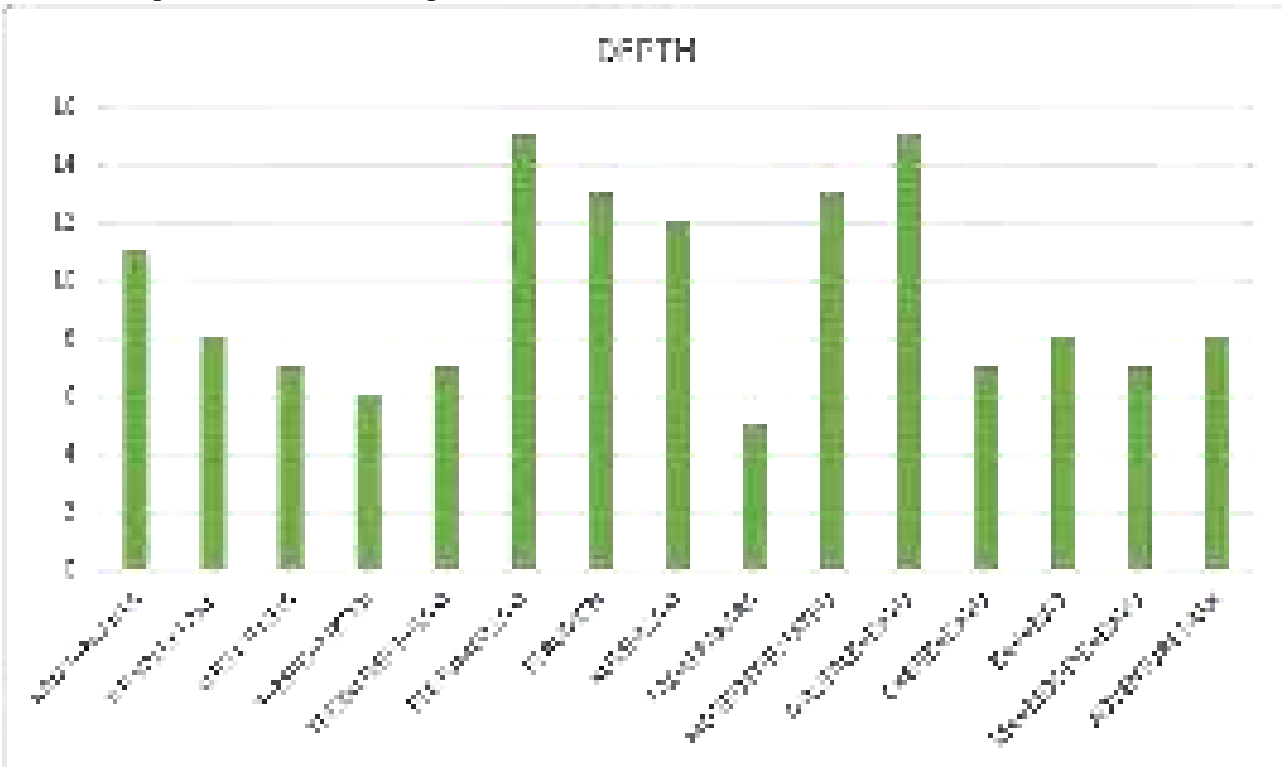
(2) TRANSPARENCY

Graph 2: Variation of Transparency in different stations of Ashtamudi lake



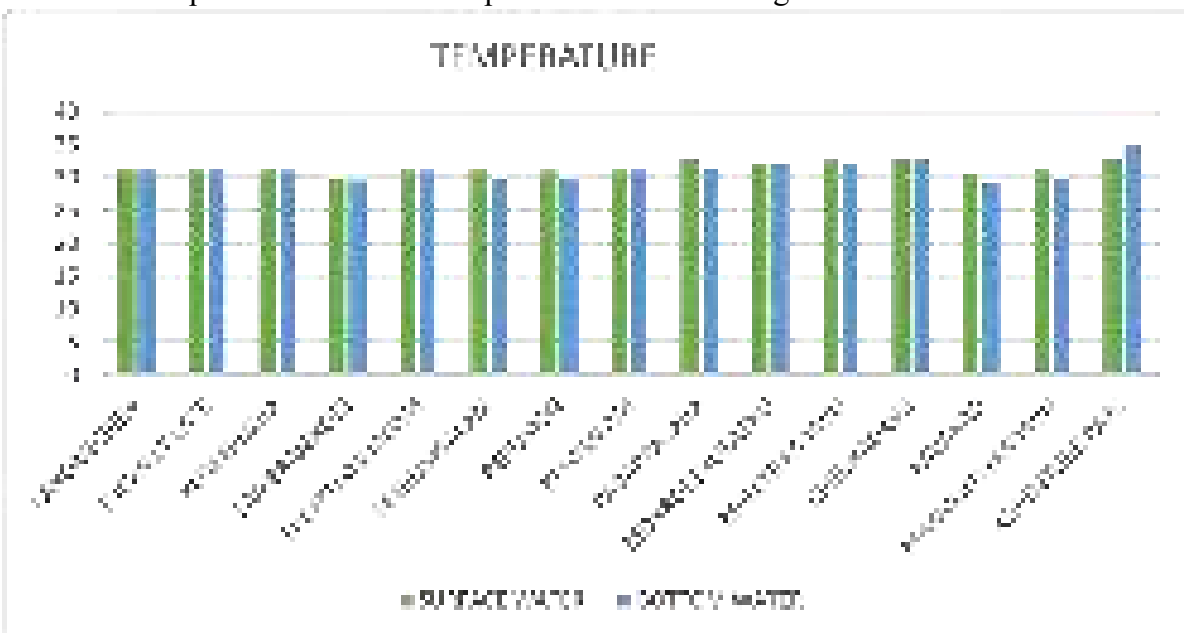
(3) DEPTH

Graph 3: Variation of Depth in different stations of Ashtamudi lake



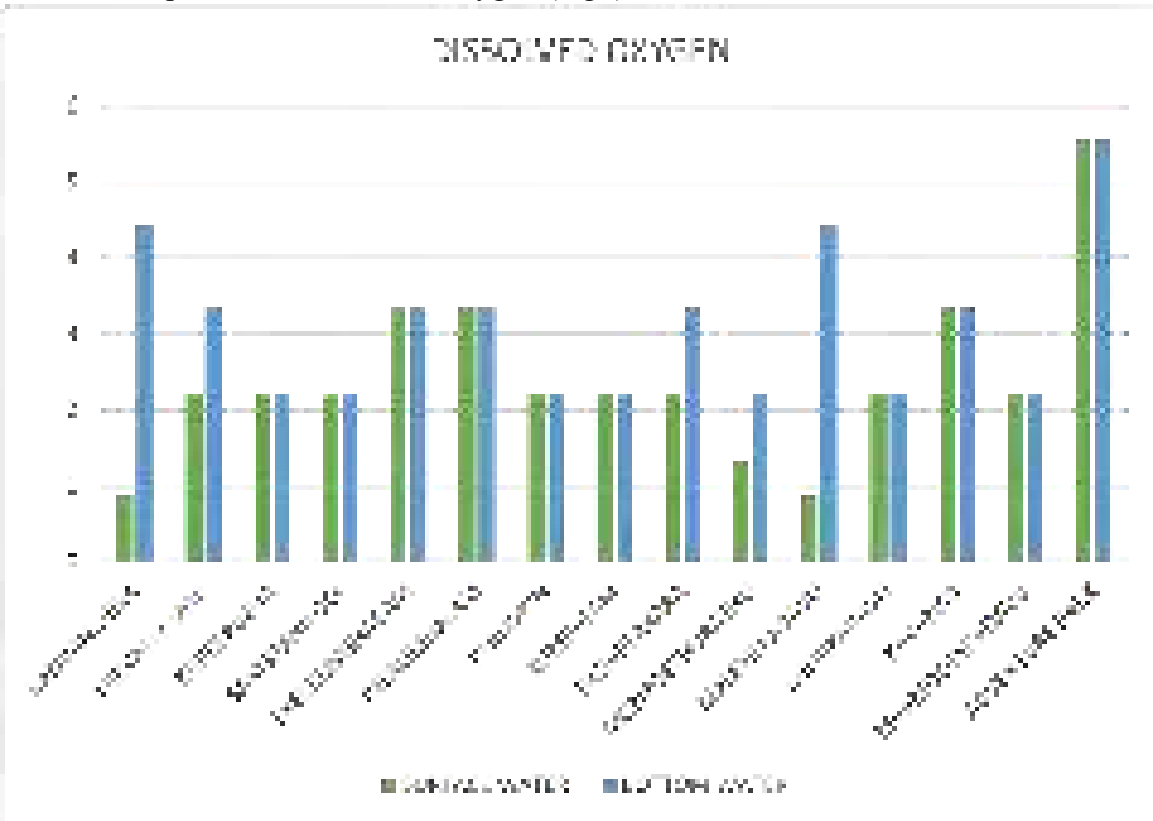
(4) TEMPERATURE

Graph 4: Variation of Temperature in different regions of Ashtamudi lake



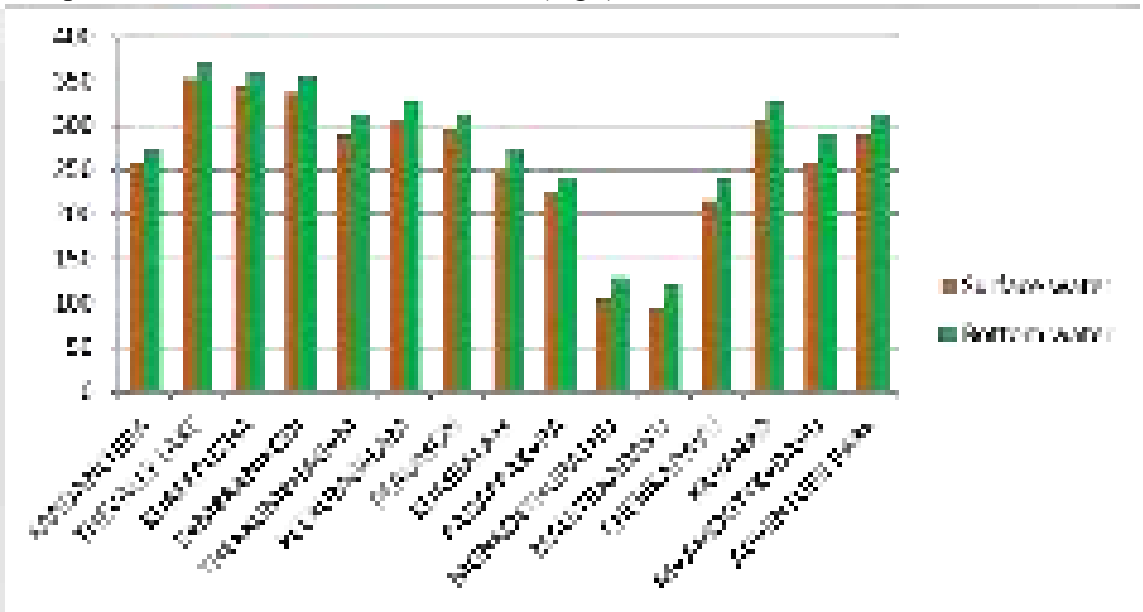
(5) DISSOLVED OXYGEN

Graph 5: Total dissolved oxygen (mg/l) in various stations of Ashtamudi lake



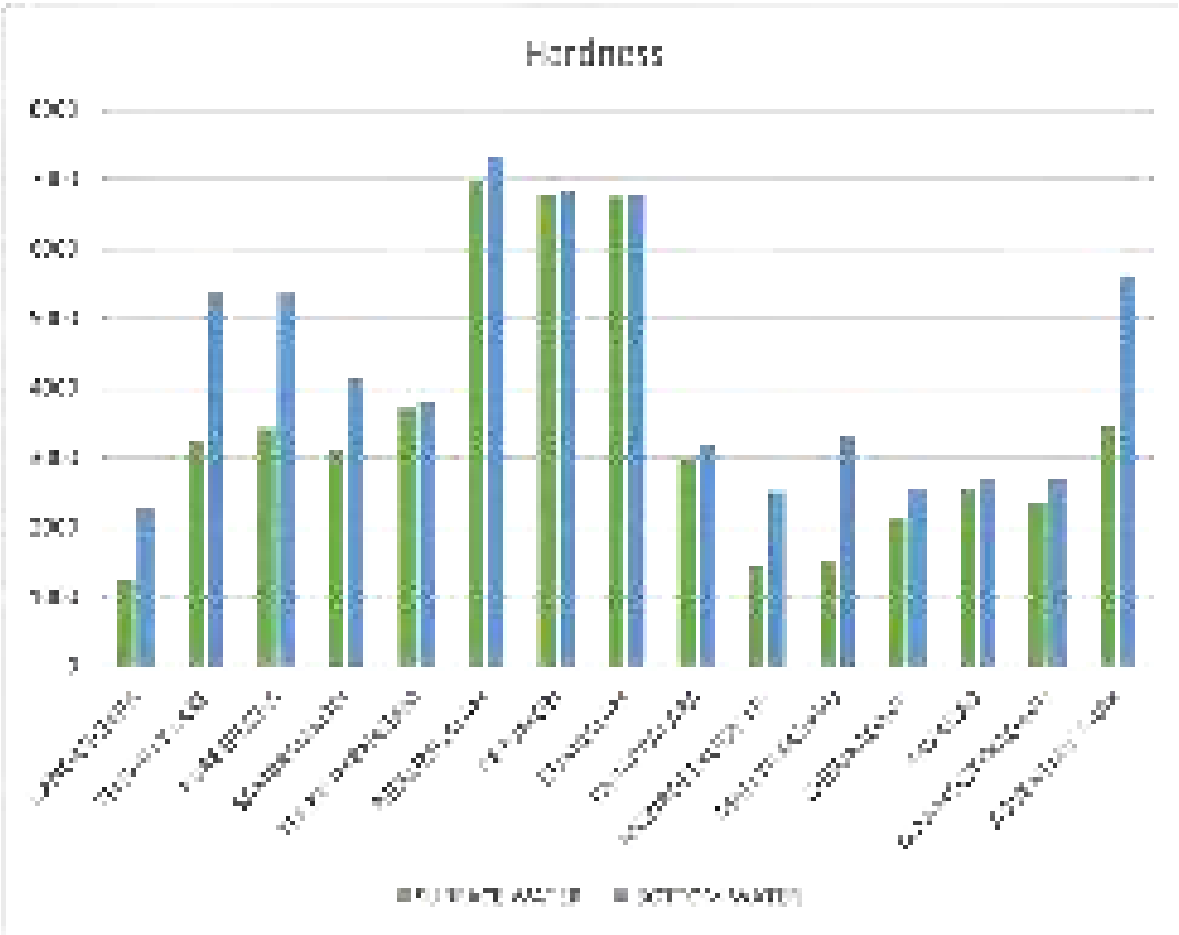
(6) CALCIUM

Graph 6 : Variation of calcium hardness (mg/l) in Ashtamudi lake



(7) HARDNESS

Graph 7: Total hardness in different stations of Ashtamudi lake



DEGRADATION OF ASHTAMUDI LAKE

The Ashtamudi Lake which is a Ramsar site is now in a pathetic condition mainly because of pollution and encroachments. The Ashtamudi Lake is now posing threat to the health of residents of the city due to the health of the residents of the city due to its high pollution levels. Untreated effluents from various hospitals and sewage from many establishments flow into it despite protests by environmental activists. The main reasons for the severe pollution of Ashtamudi lake includes:-

GARBAGE DUMPING

It is one reason for the severe pollution of Ashtamudi Lake. A parallel and illegal waste management industry has been flourishing in the district due to the absence of domestic and commercial waste treatment facilities along with the increase in non-degradable garbage left in trashes. The waste from urban settlements and commercial establishments like poultry farms and slaughterhouses is collected by agents who dump it illegally in various spots in the district, including Ashtamudi Lake. "The garbage from poultry farms is collected in sacks and carried in pick-up vans to deserted corners of the lake and dump there. The sacks usually sink, but spread throughout the waters if it is torn. Many a time, stones are attached to the sacks to keep them immersed," said A. Sudheer, a resident near the lake. Foul smell emanating from the garbage makes it impossible for the commuters to travel by the lake. The ecology of the lake is also badly hit. The agents collect garbage from various institutions for which they are paid. Environmentalists point out that hospitals in the vicinity have no proper waste treatment plants and find the lake an easy dump yard. A project to set up a sewage treatment plant in the district hospital has not yet materialised even though it was proposed years back. And if not all these are enough, the authorities have chosen Kureepuzha on the lake's banks to set up a dumping yard.

MUNICIPAL SOLID WASTE

Municipal solid waste (solid as well as domestic) and sewage from Kollam Municipal Corporation can be considered as one of the major sources for lake pollution as it uses the
Ashtamudi Lake as a waste sink. It is estimated that the latrines (including the hanging ones) of about 60% of houses near the lake are directly discharging into the lake. Unfortunately the wastedumping yard of Kollam Municipal Corporation is also located very close to the banks of the

Southern Lake at Mammoottikkadavu. The Hanging toilets are common at the entrance region, southern and central portion of the Ashtamudi Lake.

Mammoottikkadavu, near Kollam Bus Stand and Kureepuzha are the other waste dumping sites for disposing untreated waste to lake. It also contains large quantities of non-degradable plastic bags and containers. There are no proper management practices for disposing the waste from slaughterhouse and hospital in the city. The slaughterhouse in Kollam was started about 45 years back with a capacity to slaughter a maximum of 30 animals a day. The number has gone up more than ten times the originally envisaged figure; it is much more during the festival season.

SLAUGHTER HOUSE

Slaughter house has been working without following any guidelines proposed by the Corporation; it has neither developed nor maintained the basic infrastructure including a proper waste treatment plant. Environmentalists point out that the slaughterhouse is one of the main sources of pollution of the lake. The waste including the blood of slaughtered animals seamlessly flows to the lake from the slaughter house. TS Canal that passes near the slaughter house takes waste, including plastic, back to the lake during high tide.

T.S CANAL

T.S Canal is also an alarming threat to the Ashtamudi Lake, with the numerous backwaters, where waterways are successfully used for commercial inland water transport. The inland canal play an important role in the economy of the state as they interconnect rivers on the banks of which are situated places of commercial and industrial importance. The portion of this canal from Trivandrum to Ponnani and then along Bharathapuzha river up to Shornor is known as Thiruvananthapuram Shornur canal (T.S canal). The canal is highly contaminated with solid and liquid wastes; hence the need for managing, treating and disposing the sewage and solid waste is inevitable for the entire locality. After independence, with the continuous development of other models of transport, the canal traffic ceased. This resulted in subsequent negligence and consequently the pathetic condition of the canal as seen today. The name ‘parvathy puthanar’ was considered synonymous with crystal clear water, as was the case with the canal during the reign of the king of Travancore. But now due to anthropogenic activities, its ecosystem has degraded into a weed house and provided habitats for

rats, vibrio-cholera, E.coli and their mates. The quality of water has deteriorated to such an extent that the canal has begun to threaten the ground water along with the lakes at Akkulam and Veli.

WATER CHANNELS

Water channels like Manichithodu which traverses through the town and reaches the lake is a curse, especially during the monsoons. It functions as the channel for the city's waste to reach the lake. The Kollam District Tourism Promotion Council has deployed three employees exclusively to collect plastic from the lake through the channel. The 'Suchitwa
Sagaram' project of the corporation also collects plastic waste from the sea. Both the agencies, however, have not thought of setting up a mechanism to prevent the non biodegradable waste from reaching the lake.

TOURISM

Tourism is also causing severe impacts on the Ashtamudi Lake. A part of the Kerala backwaters, Ashtamudi is the second largest lake in the state. Ashtamudi wetland is an estuary and the lake forms a major geomorphologic feature of the Kollam town. It is a major tourist attraction and houseboats are a big draw. But they are also a major source of pollution because they release waste directly into the lake, says Prasanna Earnest, former mayor of Kollam. Apart from that, oil spillage from motor boats is affecting fish population. Foreign tourists in Kollam District comprised 4% and 3% of the State's foreign tourist population in 2002 and 2003, respectively. Cruise operations and traditional houseboats operate from Kollam towards east up to Munrothurthu and towards north up to Alappuzha. Speedboats operate in Asramam Kayal, which is the Southern part of Ashtamudi Lake.

THE WATER TRANSPORT SYSTEM

Water transport system is intended for providing facilities for passenger, tourist and cargo transportation at cheaper rates. Mechanized luxury boats, both Government (State Water Transport Department) and private operate from the main boat jetty (near Bus Stand Kollam) during all seasons. Ashtamudi Lake in the north and the Paravur Kayal in the south are connected with TS Canal, which form the inland water network. The National Waterway (NW-3), which lies between Kollam and Kottapuram, is passing through Ashtamudi Lake. The Water Transport Department

operate regular boat services to Muthiraparamb (West Kallada), Guhanandapuram, Ayiramthengu, Munrothuruthu and Alappuzha. Incidents of poor handling of fuel have led to oil spillages in lake water. Outboard engines exhausts are creating hydrocarbon/fuel pollution. Increase in number of houseboat operation has also lead to more direct discharge of sewage to the lake. . Oil pollution from KSRTC bus station and boats with onboard engines are another major pollutants of the lake. The worst a public sector company can do to a water body! Not to be outdone, private boat operators have set up workshops along the shores of the lake and but has no system to prevent pollutants reaching the lake. A visitor would not miss the layers of oil that cover the lake.

ASHRAMOM LINK ROAD EXTENSION

Ashramam link road extension is badly affecting the Ashtamudi Lake**.** As the Ashramam ring road extension works here enter its fourth stage connecting Thoppilkkadavu and Olayilkkadavu, the cries by environmentalists against violating the Coastal Zone Management Rules have fallen on deaf ears. The authorities still proceed with the road which is virtually irrelevant with the opening of Kollam bypass. Filling Ashtamudi Lake violating environmental norms will adversely affect the ecology.
"The need for such a road by filling the lake itself is a matter of debate," V.I. Rahul, an environmental activist who challenged it in Kerala High Court, told DC. "The authorities say the 2.75-km road will ease the traffic along the 1.6-km stretch connecting collectorate junction, high
school junction, and Kollam bus stand. But the bypass has made it irrelevant." As the area falls under CRZ (coastal regulatory zone)-II and the lake is a Ramsar site, it needs the permission of the state's department of environment and climate change based on Wetland (Conservation and Management) Rules 2010.The project has not obtained sanction from Coastal Zone Management Authority either. In reply to an RTI query earlier, the KCZMA has maintained the office holds no details on the permission for construction along the lake as part of phase III of link road extension. Though authorities claim the construction is on pillars, the tidal flow is likely to get affected. The lake has also been extensively filled in bus stand junction and Olayilkkadavu areas. The construction from Kollam KSRTC terminal to Thoppilkadavu via Olayil Kadavu is entirely through the Ashtamudi Lake. Pillars have been erected in the lake up to Olayil Kadavu for Phase III. The Phase
IV which is in the initial stage involves the construction of a flyover from Olayil Kadavu to Thoppilkadavu. Around 8 acres of the Ashtamudi Lake has been encroached and filled for the project.

The Link Road was constructed in the lake by destructing a forest cover that had eight species of mangroves. Destructing these trees affected the natural purification of water. The concentration of bio and heavy metal waste in the soil is increasing as the natural purification process

is obstructed by the concrete structures. “The CRZ norms had also proposed that the inter-tidal zone should never be disturbed for the protection of Mangrove vegetation, but they were never followed.

SAND MINING

It is conducted in the Kallada River zone and along the northern shore of Ashtamudi lake. The sand mining activity will lead to deepening of the riverbed, which will reduce the natural filtering capacity of river. In addition it will increase the rate of bank erosion and saline water intrusion. The present rate of mining of the eastern Kayal may not be sustainable due to a lack of sediment output from the Kallada River. The estuary is primarily infilling from the sea. The entrance and western portion of the Ashtamudi Lake is shallow and sand rich. For the marine ecology, it is beneficial to mine from the specific areas for 1-2 seasons and then to move to another site, rather than mining from the same area. This allows most of the habitat to remain intact and provides a suitable recovery time of the areas being mined. Shell mining is another livelihood activity dependent on the estuary, which is largely located in the Central portion of Ashtamudi Lake.

OIL POLLUTION

Oil pollution from KSRTC bus station and boats with onboard engines are another major pollutant of the lake. The worst a public sector company can do to a water body! Not to be outdone, private boat operators have set up workshops along the shores of the lake and but has no system to prevent pollutants reaching the lake. A visitor would not miss the layers of oil that cover the lake.

AGRICULTURE

Agriculture is another source of pollution. The runoff from agricultural fields in adjoining areas is adversely affecting the Ashtamudi Lake. Chemical fertilisers and pesticides are causing eutrophication of the lake. Agriculture expansion accompanied by intensive use of agro-chemicals has become a major driving force for encroachment, reclamation, pollution, water eutrophication, and biodiversity-loss for the Ashtamudi Lake. The fertilizers used for the crops are seeping to the lake, which causes pollution.

THE UNSCIENTIFIC DREDGING

The unscientific dredging of Ashramam Lake along 1100 meters for the boat race and the deposit of residue in the lake alone have affected the smooth process of high and low tides. The extension of Link Road to Olayil Kadavu starting near the DTPC building was completed violating the CRZ norms. The ministry of environment and forests had given permission to construct the road on pillars without disturbing the Lake and associated biodiversity. However, a massive area of 6.5 acres was filled near the slaughterhouse end for the road.

CONCLUSION

Kollam is the only revenue district in India with the glory of two wetlands declared as Ramsar sites, The Ashtamudi Lake and the fresh water Sasthamkotta Lake. The shores of Ashtamudi estuary are home to thousands of people and become the bio spots of Kerala by sheltering large species of flora and fauna. But now, the Ashtamudi lake has now become one of the worst victims of human avarice and disdain for environment. Its very existence is under threat now: the area has shrunk; it's being encroached upon, and being made a waste dumping yard. Its water has lost its quality. The future of this lake will be significantly affected by decisions made today concerning the lake's resources and its sustainable development. The present study revealed that the Ashtamudi Lake is highly polluted, since the values of physicochemical parameters observed are beyond the permissible limits. It is mainly due to several anthropogenic influxes particularly that of solid waste dumping in its banks. A healthy ecosystem makes no waste as the discards of one species become food for the next, in an endless cycle, but the modern society interrupts these cycles which will badly affect our existence too. So it is our duty to protect this Ramsar site, whose luscious beauty was once an inspiration to the poets.

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POLLUTION STUDY OF SASTHAMKOTTA LAKE

INTRODUCTION:

Water is an essential component for survival of life on earth, which contains minerals, important for humans as well as for world and aquatic life. Lakes and surface water reservoirs are the planet' s most important freshwater resources and provide in numerable benefits. They are used for domestic and irrigation purposes and provide ecosystems for aquatic life especially fish, thereby functioning as a source of essential protein and for significant elements of the world' s biological diversity. They have important social and economic benefits as a result of tourism and recreation, and are culturally and aesthetically important for people throughout the world. They also play an equally important role in flood control. However, the remarkable increase in population resulted in a considerable consumption of the water reserves worldwide. The quality of surface water is largely affected by natural processes (weathering and soil erosion) as well as anthropogenic inputs (municipal and industrial waste water discharge). The anthropogenic discharges represent a constant polluting source, whereas surface runoff is a seasonal phenomenon largely affected by climatic conditions. In this modern world it is no longer safe to use water from natural resources. The quality of surface water is unpredictable because the water continually moves and pollutants can be introduced at any time. In other words, an area of the lakes or streams that is fine one day may be contaminated on next day. Water quality evaluation is considered as critical issues in recent years, especially when fresh water is becoming a scarce resource in the future. Water quality indicates the relation of all hydrological properties including physical, chemical and biological properties of the water body. Hence, water quality assessment involves analysis of physico chemical, biological and microbiological parameters that reflects the biotic and abiotic status of ecosystem . Water quality monitoring has a high priority for the determination of current conditions and long-term trends for effective managements. The supply of safe water has a significant impact on the anticipation of water

transmissible diseases. Clean and adequate water supply is a necessity for the health of all living organisms and ecosystems, including people and their activities. Water quality monitoring has one of the highest priorities in environmental protection policy to control and minimise the incidence of pollutant – oriented problems, and to provide water of appropriate quality to serve various purposes such as drinking water supply, irrigation, recreational and industrial; and to protect the valuable freshwater resources to safeguard public health Sasthamcotta Lake is the largest natural fresh water lake in Kerala also called "Queen" of Lakes. The Sasthamcotta wetland is incorporated in the list of wetlands of international importance by the Ramsar convention for the conservation and sustainable utilization of wetlands. A lake is a large body of water surrounded by land and inhabited by various aquatic life forms. Lake is a reflection of its watershed. Like water shed landscape, the topography, soil, geology, and vegetation determine the kinds of materials entering into the lake that in turn reflect on its water quality. Sasthamcotta Lake is now facing degradation due to anthropogenic activities leading to the deterioration of environmental quality as well as a decrease in surface area and depth. Various sources of pollution are the extensive soil erosion caused mainly by agricultural activities, pollution caused by pesticides and fertilizers, human faecal contamination, animal waste and chemical contamination, encroachment on part of lake for agriculture, domestic waste from surrounding areas disposed into lakes, sand and clay mining, tourism activities, and inland navigation, oil and paint from boat building yards, soaking of dry leaves of coconut palm before matting, effluent from water treatment plant , fishing activities, construction activities around the lake cause debris to fall in lake, excess growth of algae and so on. Many research studies have been carried out regarding hydrological features of the lake But most of them are not concentrated on water quality and other environmental features. Very few studies reveal the physical, chemical and biological characteristics of the lake. Recent research has further shown that change in climate and subsequent change in water use will further stimulate the pollution in lakes. There is therefore a growing demand for lake restoration and insight in sustainable

lake management. The main objective of this study is to assess the present water quality scenario of Sasthamcotta Lake. (Divya and Kani 2018).

OBJECTIVE:

#To check the status of the Lake in water quantity and quality.

#To identify the major causes of degradation and depletion of the lake.

#To analyze the opinion of the local people regarding the degradation of the lake.

To suggest rejuvenating measures to keep the Lake sustainable.

REVIEW OF LITERATURE:

George and Koshy (2008) conducted the water quality study of sasthamcotta lake. The lake is facing degradation due to anthropogenic activities such as directing human waste, soil erosion due to destruction of vegetation and dumping from hotels.

George and Jayakumar (2011) analyzed the human intervention in the lake catchment area and they study the siltation, sedimentation, and pollution affecting area of the lake. Peter and Sreedevi (2013) studied the quantitative evaluation of sasthamcotta lake by using GIS and they predict the future pollution level and its impacts.

Sujayakumari and Lisy (2017) compared physical and chemical parameters and two bacteriological parameters such as total coliform and Escherichia coli for Sasthamcotta lake water and Kallada Irrigation Project (KIP) canal water. Physical and chemical parameters and two bacteriological parameters such as Escherichia coli and coliform of water from Sasthamcotta Lake and Kallada irrigation project canal reveal that both glasses of water are unfit for drinking without sufficient purification. Human excreta are the main cause of fecal pollution. Encroachment of the Lake for agriculture, especially for tapioca reduced the soil by erosion in the catchment area.

Munisha *et al.* (2019) estimated the microbial contamination of water, sediment and benthic community of the lake. Bimonthly collections of surface and bottom water and sediment samples.

Bindhya *et al. (*2021) explained the impacts of synthetic fertilizers on soil, water and air pollution and the possible sustainable solutions which are to deployed in order to reduce or eliminate such constraints.

Anila (2021) assessed the quality of public water supply distributed through a distribution network of various panchayats of Kollam district. The paper focuses on the Japan drinking water project, which has successfully installed in Kerala. The study was conducted at six stations which include four Panchayats with Japan drinking water household pipeline connection, the source (Kallada River) and treatment plant. An expert committee appointed in 2010 under the leadership of Executive director of CWRDM for finding out the reasons of drying up of the Lake. The committee found that 50 tonnes/hectare/year deteriorate in 199 itself and it has extended due to human intervention. The clay, sand and laterite mining in the catchment area of the Lake forced the groundwater outflow from the Lake. The agricultural practice also reduces the reservoir capacity of the Lake. A large part of the Lake has reclaimed into agricultural (Ajith Varghese George, 2008). Increasing mining in Kallada river due to high foreign remittance and liberalized foreign policies result in increasing demand for construction materials which affect Sasthamcotta Lake. Alluvial sand mining and uncontrolled water abstraction from the Lake resulted in declining water level in the Lake and nearby wells (Padmalal, 2014). The catchment area of the Lake is quite small. Hence the rainwater availability is limited. Through various rural water supply schemes and evaporation, the estimated water loss in the Lake is 12.9 million (Soman, 2002). Another study also criticise Irresponsibility of the local government towards the protection of the Lake, sand mining of the Kallada River and its consequences in Sasthamcotta Lake points out under the title of public loss and private gain (Mohammed Irshad,2015).

MATERIALS AND METHODS:

Study Area The study area is Sasthamcotta Lake located in Kollam District, Kerala, a state of India on the south of the west coast. The lake is located physiographically in the midland region between 90 0' - 90 5' N latitude and 760 35' - 760 46' E longitudes at an elevation of 33m above MSL. The lake has a catchment area of 12.69 km2, surface area of 373 hectares, average depth of 6.53 m, maximum depth of 15.2m and a storage capacity of 22.4 km cube.

This area is selected for study because this lake is a drinking water source for over 700000 people in Kollam district. An alarming fall in water level and pollution has put the biggest fresh water lake in Kerala at risk. According to Wetland Conservation and Management Rules, 2010 by the Ministry of Environment, Forest and Climate Change, the water bodies listed under the Ramsar convention Centre are not to be polluted or encroached upon. But in the case of Sasthamcotta Lake various Governmental, private bodies and people living closely to the lake have been polluting and encroaching the lake.

Water Sampling and Analysis Based on habitat assessment the study area is divided into three sampling locations of approximately equal area. Water quality of lake is tightly depending upon all the activities taking place at its bank. With expert' s advice and Based on the activities such as pollutant intrusion, runoff entry points, onsite activities like huge gathering, agricultural, livestock and laundry activities, six different sampling points were selected within each location as shown in figure 2. Depth wise sampling is also carried out as shown in figure 3. The specific activities at selected sampling points are given in table 1. Water samples were collected during second week of each month (April and May 2022). Sampling, preservation, and assessment of the water quality were carried out as per standard methods. water quality parameters were selected on the basis of pollutants discharge and its effect on Lake Ecosystem and on human health. This is carried out by judgement of professional experts, agencies and government institutions that is determined in the legislative area. The selection of the variables from the 5 classes namely oxygen level, eutrophication, health aspects, physical characteristics and

dissolved substances, which have the considerable impact on water quality, are recommended. In this study Parameters were selected based on the site-specific actions and experts' advice and are given in table.

RESULT:

The water samples were taken from 27 stations from the month of April 2022 to May 2022 and the Characteristics of physico chemical and biological parameters of studied water samples are shown.

To the entry of runoff that comes through or over soil and rocks which are capable of releasing ions, Waste water discharge from agricultural fields and presence of higher concentration of acids. Solids refer to the suspended and dissolved matter in water. They are very useful parameters describing the chemical constituents of the water and can be considered as edaphically relation that contributes to productivity within water body. The total dissolved solids (TDS) in the sampled water ranged from 86.5mg/L in April to 53 mg/L in May 2022. The highest value of TDS during rainy period was due to the addition of organic matter and solid waste into the lake. The high value of TDS during rainy season may be due to addition of domestic waste water, garbage and sewage etc. in the natural surface water body. In this study TDS concentration of all water samples were below the desirable limit (500 mg/L) given by BIS. Temperature is a measure of how much heat is present in water. Temperature can vary throughout the lake, with surface water affected more by air temperature than deeper water. Water temperature is one of the most important physical characteristics of aquatic ecosystems and affects a number of water quality parameters.

In this study the temperature of surface water samples was ranged from 270C to 31.20C in April 2022, 26.90C to 300C in May 2022, and the temperature of water samples collected from depth was ranged from 22.50C to 24.9 0C in April, 23.10C to 25.90C in May 2022. Water temperature may depend on the seasons, geographic location and sampling time. Temperature of lake water was observed to be a function of depth, time of the day, and exposure to direct sunlight Turbidity is a measure of the intensity of light scattered by suspended particles. Clay, silt, organic matter, phytoplankton, and other microscopic organisms cause turbidity in pond water. Turbidity blocks out the light needed by submerged aquatic vegetation. It also can raise surface water temperatures above normal because suspended particles near the surface facilitate the absorption of heat from

sunlight. The extent of turbidity in an aquatic system is generally taken as a measure of pollution intensity. In present study turbidity exhibited 15 NTU as highest value in April at sampling point S18 while in May 2022 it is reduced to 10 NTU. Least value of turbidity was found to be 0 NTU during April and May 2022 at sampling point S5. The highest values were recorded during april which might be due to the entry of runoff and eroded soil particles. Highest value of turbidity other than rainy season may be due to the presence of higher number of microscopic organisms. The higher value of dissolved oxygen indicates good aquatic life [3]. DO is indicative of the health of an aquatic system, the vital metabolism of aerobic organisms, respiration depends purely on the amount of oxygen dissolved in the water. Optimum concentration of dissolved oxygen is essential for maintaining aesthetic qualities of water as well as for supporting life [30]. In the present study concentration of dissolved oxygen was found to be higher. The concentration of dissolved oxygen ranged from 5.27 to 8.92 mg/L.

April 2022, 4.459 to 7.7 mg/L in May. During rainy seasons, oxygen concentrations tend to be higher because the rain interacts with oxygen in the air as it falls. The biochemical oxygen demand is the amount of dissolved oxygen required by the aerobic biological organisms to decompose organic matter present in the given water sample at certain temperature over a specific time period. In this study BOD values reported were ranged from 4.87 to 1.62, 4.46 to 2.03, 3.65 to 1.22 and 3.25 to 0.81 mg/L. The maximum amounts were recorded during April and minimum values were recorded during may. Highest value of BOD was observed during April at sampling points S12 and S15.

Lowest value of BOD was reported during may at S5 and P6. Houses and hotels around the lake dump their food waste into the lake may be a reason for high BOD. The maximum values of BOD during April were due to input of organic waste and enhanced bacterial activity. The reason of high BOD in monsoon might be due to presence of several microbes in water bodies, which accelerate their metabolic activities with the increase in concentration of organic matter in the form of municipal and domestic waste which discharge into water bodies and so the demand of oxygen increased. Chemical oxygen demand (COD) determines the oxygen required for chemical oxidation of most organic matter and oxidizable inorganic substances with the help of strong

chemical oxidant. In conjunction with BOD, the COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances. COD values in Sasthamcotta Lake water was 24 to 108.8 mg/L (April 2022), 5.448 to 19.976 mg/L (may 2022). The present study revealed that the COD values of the water samples in April 2022 appear to be higher than desirable limit (10 mg/L) for drinking water recommended by WHO. In May 2022 the COD values of some water samples exceeds the desirable limit. The COD values showed a decreasing trend from April 2022 to May 2022. It might be due to the intrusion of pesticides, fertilizers, agricultural waste, hospital waste and other dumped waste along with rain water into the lake The total hardness of water is not a specific constituent but is a variable and complex mixture of cations and anions. Hardness of water prevents lather formation with soap and therefore hard water is not suitable for bathing and washing. Hard water has high boiling point and hence it is not suited for cooking too. The total hardness and calcium hardness levels in sasthamcotta lake varied from 8 to 16 mg/L and 6 to 10 mg/L (April 2022), 8 to 18 mg/L and 6 to 10mg/L (may 2022).

This study revealed that both the hardness decreased from April 2022 to May 2022. Less values of hardness is reported in April which may be due to the dilution of lake water with rain water. Both the hardness values in all water samples were below the desirable limit of 300 mg/L recommended by BIS. Calcium is an important nutrient for aquatic organism and it is commonly present in all water bodies. Its concentration varies greatly in natural waters depending upon the basin [16]. Magnesium is often associated with calcium in all kind of water but its concentration remains generally lower than the calcium. Magnesium is essential for chlorophyll growth and acts as a limiting factor for growth of phytoplankton. The amount of calcium and magnesium of sasthamcotta lake water samples ranged between 2.4048 to 4.008 mg/L and 0.486 to 2.43 mg/L (April 2022, 2.45 to 4.08 mg/L and 0.486 to 2.43 mg/L (May). According to BIS the desirable limit of Calcium and Magnesium for drinking water is 75 and 30 mg/L respectively. The present study revealed that the concentration of Calcium and Magnesium present in all water samples were within desirable limit. The lowest amount of calcium in water was due to calcium absorbed by the large number of organisms for shell construction, bone building and plant precipitation of

lime. The lowest value of Magnesium was due to the magnesium essentiality for chlorophyll bearing plant for photosynthesis.

Chloride is one of the major inorganic anions in water. From the present study chloride content in water samples were ranged between 14 to 23 mg/L during study period. Lowest value of chloride was observed. It might be due to the dilution of lake water by rain. Highest value was observed in April .it might be due to the evaporation of fresh water from lake. In all natural water sulphates are found. Water with about 500 mg/L sulphate has a bitter taste and those with 1000 mg/L or more may cause intestinal disorders. The sulphate content in the lake varied from 48 to 58 mg/L (April) 45 to 54 mg/L (May). In this study sulphate concentration decreased from April to May 2022. The highest value of sulphate was recorded in April. It may be due to the decay of plants. Sulphate values in all water samples were below the desirable limit of 200 mg/L recommended by BIS for drinking water.

The coliform bacteria include the genera Escherichia, Citrobacter, Enterobacter, Klebsiella etc. Coliform bacteria may not cause disease, but they are used as one of the indicators of pathogenic contamination that can cause different diseases like dysentery, intestinal infections, typhoid fever, hepatitis, cholera, and other illness.

According BIS for drinking water quality, the drinking water should be devoid of coliforms. In this study the total coliforms ranged from 17 to 22400 count / 100mL (April 2022, 21 to 22400 count / 100mL (May), 2022. The high total coliform counts indicate that the lake is exposed to human faecal contamination, animal waste and chemical waste because of human settlements near the lake.

DISCUSSION AND ANALYSIS:

Drying up of the largest freshwater Lake of the state of Kerala namely Sasthamkotta Lake, progressively during last two decades were clearly visible in satellite images from Google Earth Pro As per the result obtain from google earth all of these photographs were indicating a gradual decrease in the quantity of water and transformation of land use of these areas for other purposes like agriculture, construction of buildings etc. Water channel measurements showing water fulfilled and extremely dried periods of the Lake. From this analysis an 5 area about 316,600 Sq. Km was dried with a perimeter of about 3,500 Km of dried land. This shows a decrease in the distance in the water channel due to the drying of the Lake from 733 meter to 353 meters. This will adversely affect the boat service and tourism part of the Lake.

Rainfall The region in which the Lake belong facing a warm tropical climate. The two prominent monsoon systems namely South-West (June-August) and North-East (October-November) contributing extensively to the status of rainfall of the region. The area received a mean annual rainfall of 2487.1 mm (1901- 1999). The occurrence of annual rainfall shows large variations such as the highest 4780 mm (1979) and the lowest of 897 mm (1982). The Lake gets its water from direct rainfall over the Lake, run-off from the upper catchments, and subsurface runoff/underground recharge, comprising the base flow from the catchment as well as from the extensive groundwater storage of the tertiary sedimentary province spreading outside the catchment, and recharge from the floodplain lying to the south of the Lake.

However, the main sources of water are direct rainfall and underground recharge. (Jayakumar et.al 2018). These reports suggesting an undulating type in last 12 years with a maximum of mm in 2011. Instead of alternative increasing and decreasing of rainfall in this region, it shows an overall negative trend in rainwater availability status. 3046 mm in

2006 and a minimum of 1655.5 the inflow of water in the present Lake mainly depends upon the rainwater. So, the negative trend in the availability of rainfall in last 12 years indicating a rainfall deficit which is largely influence the water balance status of the Lake and the outflow of water from Lake is mainly occurred due to spillage, groundwater seepage, evaporation from the Lake surface and draft by Kerala Water Authority (KWA) for drinking water supply. This outflow of water from the Lake is in an increasing mode due to these several reasons. So, during the periods of minimum availability of rainfall the Lake faced maximum drying up. The soil is the most fundamental and basic natural resource for all life to survive. Water and wind erosion are the two main agents that degrade soils. Geologic erosion is a normal process of weathering that generally occurs at low rates in all soils as part of the natural soil-forming processes. Soil erosion is an important social and economic problem and an essential factor in assessing ecosystem health and function. The soil erosion and resultant siltation is another major threat faced by the Lake. The Lake is physically surrounded by the steep slopes on three sides and a man-made bund in the southern side separating it from the low-lying paddy fields. The steep slopes of the hillocks around the Lake are understood by the help of Elevation Profile tool in Google earth pro. Ten paths were randomly drawn across the Lake and elevation profile was determined. This indicating steep slopes of the hills that will lead to the down-slope movement of rock and sediments, mainly due to the force of gravity and influence of water. Google earth image itself showing several buildings and construction works in this catchment area. This will also enhance the rate of erosion. The laterite mining activity in the hills initiate the hard formations to be loosened and further movement when rainy Periods. The unscientific agricultural activities and plating of acacia Figure 1.5 Ten paths along the lake and their alternative elevation profile shows steep slope, supporting gravity movement of eroded sediments and direct evidence of soil erosion. 8 Trees around the Lake also

lead to the fasting of soil erosion and siltation of the Lake. The studies were done for Indo Norwegian water plan reveals the depth of the Lake was 35 meters before 51 years ago. And the survey conducted in 1980 point out it was 15 meters. As per the data from Ministry of Agriculture, Kerala 50 tons per hectare of soil eroded to the Lake in every year. But the studies of CESS says the depth of the Lake declining at an alarming rate.

Water extraction: Sasthamcotta Lake is a drinking water source of around seven lakhs' peoples in Kollam Municipal Corporation. The Quilon water supply schemes started at the beginning of the 1960S. Later the Sasthamcotta-Sooranadu rural water supply scheme initiated for pumping water from the Lake to Sasthamcotta, Sooranadu panchayats. The vertical turbine established by the KWA in 1990 and install the additional pump in 2010 due to the high drought condition. At present, 250 HP motor working in 24 hours, 150 HP motor working in 12 hours, and 100 HP motor working in 12 hours. And 35 million liter water extracting the water authority per day. Out of this, 110 lakh liters for Sasthamcotta and Sooranadu, 90 lakh liters for Chavara-Panmana scheme. In the protesters, media reported that the water extraction from the Sasthamcotta Lake is an alarming rate. Within the time of the peak level of strikes for the protection of the Lake, a new drinking water scheme of Chavara – Panmana commissioned under the leadership of N K Ramachandran (Member of Parliament). It forced the depletion of water as well as strikes. An alternative plan of Kallada Irrigation Project (KIP) started instead of taking water from Sasthamcotta Lake. But it is not properly implemented due to land acquisition issues of local peoples and an adverse verdict from the court. The water level is coming down at the rate of 50 cm in each year (Deccan Chronicle,15th May 2018). The separate data regarding the income and expenses of taking water and pumping to the public by Kerala Water Authority (KWA) from Sasthamcotta Lake is not available due to taking water for pumping is the mixer plans of different water sources which include Sasthamcotta is one. But data from the personal interview shows around 7.5 crore rupees is the revenue of KWA getting from water supply per year. Out of this, 75 lakhs from Chavara – Panmana scheme. Out of this income, they were nothing to doing for the Lake protection. As per the data from KWA in 2017,

the current Lake water depth is 37.5MLD. In the words of protesters, the downfall of the Lake started with the starting of Quilon water supply schemes.

Mining: The laterite soil also preserves the rainwater in monsoon season and release it in summer. But the past studies prove the uncontrolled mining of laterite soil in the catchment area of the Lake is a reason for the depletion of the Sasthamcotta Lake. In the direct visit and peoples, responses reveal that the Vilandara area near Karalimukku has identified the major point the literate mining was happening. There are six cases came in front of the court against the mining activities between 19982009. As per the report from the Mining and Geology Department of Kerala, they allow the permission for laterite mining only for housing construction. They agreed that 2800 transit pass issued for mining in the catchment areas. Besides that, the report shows there is no cases registered related to illegal mining. But due to the strictness of environmental clearance in the recent periods mining not allowed now. It gives the prospects of lives of the Lake. District collector forbids any type of mining activities around the catchment areas of the Lake in 2017. As per the report from the Mining and Geology Department, there are no mining activities allowed except rock near Sasthamcotta area. Even though their view is quite different. They say mining is necessary for infrastructural development. The penalty for illegal mining is only 25000 to 30000. It reveals that everyone can engage in mining activities by paying off the penalty mentioned above. Generally, mining-related cases hand over to State mining and geological department and it' s solved with a penalty. The mining of Cheloor Lake near the Sasthamcotta Lake is another threat of the Sasthamcotta Lake.

Water Quality: The important factors that affect the quality of water are climate variation, depth of water from the surface, hydrologic parameters and chemical makeup of sediments through which the water moves. Anthropogenic influence also affects the water quality in a significant manner. Water being an excellent solvent, it is imperative to be acquainted with the geochemistry of the dissolved solid constituents.

The water quality analysis of Sasthamcotta Lake was carried out by many people in the past several years. A recent water quality analysis data was obtained from Water authority Department of Sasthamcotta through Right to Information Act 2005, and compare this data with the previous study to understand about the status of water quality of this Lake. The available data on water quality parameters were used to correlate the present and past status. This includes pH, Turbidity, Electrical Conductivity, Total Hardness, Calcium, Magnesium, Acidity, Alkalinity, Sulphate, Fe2+, Chloride, Fluoride, Total Coliform and Total Dissolved Solids.

The pH is the hydrogen ion concentration, which expresses the scale of intensity of acidity or alkalinity of water. The pH value of natural water is a measure of its net alkalinity and acidity. The pH values range from 0 to 14. If the pH is below 7 (pH <7) then the water is acidic and the pH is above 7 (pH >7) then the water is basic in nature.

The pH of the value of water from Sasthamcotta Lake in the 2006-2007 and 2017-2018 periods are compared. The BIS limit is ranging from 6.5 to 8.5 for fresh water which is suitable for drinking purpose. The Lake water is suitable for drinking purpose according to the pH in the 2006-2007 period. But now the value reduced from 7.27 to 4.2 in an acidic trend. Acidic water can leach metals from pipes and fixtures, such as copper, lead, and zinc. The metal content in the drinking water causes several health issues. And also, it will affect the aquatic organisms which live in the Lake. The low pH value may be due to the rusting of pipes which were the unused materials of the Kallada irrigation project, Pesticides used for the rubber plantation around the Lake, stagnation, and death of algae.

Electrical Conductivity

Electrical Conductivity of water is owing to the actuality that water is an electrolytic solution. EC is unswervingly proportional to the number of dissolved salts. The EC denotes the characteristic of a medium to the passage of electricity. In water quality determination, conductivity is defined as the conductance of a cube of the one-centimeter side of a substance is expressed in months/cm. Electrical conductance of water is a function of temperature, type, and concentration of various ions.

Total Hardness

Hardness is the quality in water, which destroys the property of soap to form a lather. There are two types of hardness in surface water: Temporary or carbonate hardness and permanent or non-carbonate hardness. The combination of both of these types constitutes total hardness. Total Hardness has a great role in determining the quality of the water. According to BIS, the permissible limit of Total Hardness of water suitable for drinking is 300-500 mg/l. The water from the present Lake is within this limit in both periods.

d. Total Dissolved Solids.

TDS refers to all solid materials present in solution either in ionized state or in nonionized state and exclude the suspended colloids or dissolved gases. Quality of drinking water will be affected by the presence of soluble salts. TDS indicate the general nature of water quality or salinity. Therefore, the level of TDS is one of the characteristics which decide the quality of drinking water. The Lake water has a TDS value within the permissible limit of BIS in both periods. But the TDS

status of the water in an increasing manner. This increasing trend may be due to the addition of domestic wastewater, garbage and sewage etc. to the Lake.

Turbidity: Turbidity is a physical parameter that determines the cloudiness or clarity of the water. It is measured in NTUs or nephelometric turbidity units. Water with noticeable or measurable turbidity is generally unfit for drinking. The drinking water quality standard for turbidity is 10 NTUs according to BIS and excessive levels can block light from reaching aquatic plants, increase water temperatures and create muddy-bottomed streams uninhabitable for many types of aquatic life. Some common sources of turbidity include erosion from stream banks,

contaminated runoff high in sediment from roads or areas with little or no vegetation, or plant particulates from streams choked with algal or other aquatic plant blooms. The Turbidity level in both periods is permissible within the BIS and can be used for drinking purpose. But the value in an increasing trend. This may be due to the soil erosion from the hillocks around the Lake. f. Chemical Constituents

Calcium :(Ca^{2+}) Calcium is a major constituent of most igneous, metamorphic and sedimentary rocks. And important constituent in determining the quality of water. As per BIS index the permissible limit of Ca^{2+} in water is 75 ppm and may be extendable up to 200 ppm. The value of Ca^{2+} in water of the present Lake lies in the permissible limit.

Magnesium: (Mg+) The source of magnesium in natural waters is from chemical weathering of rocks and chemical fertilizers. It is generally found in low concentration than Calcium. The concentration of mg above 150 mg/l if present with sulfate may cause gastrointestinal problems and diarrhea. The value of Mg+ in present Lake in tow periods of decadal interval shows an increase from 2.64 to 4 mg/L. These values lie within the drinking specification in both.

Sulfate (SO42-): -

The sulfate content of atmospheric precipitation is only about 2ppm. Sulfur is not a major constituent of most of the rocks; however, sulfate is abundant in most groundwater. This happens througTurbidity of Lake water undergoes oxidation, reduction, precipitation, solution and concentration processes as water traverses through rocks. Natural water contains higher levels of sulfate contributed from the weathering of rocks. In addition to this, domestic sewage and industrial effluents also add sulfate to the aquatic ecosystem and hence high level of sulfate is an indicator of organic pollution. The decadal comparison of SO42shows a gradual increase in its content from 0.1 to 23.6 mg/L. Both the values lie within the permissible limit but the increasing trend shows a serious problem. This increase in Sulphate content may be due to the weathering of rocks in the hills around the Lake and also due to the unscientific sewage system.

Iron (Fe2+): -

Iron can be an annoying chemical in water supplies. Making up at least 5 percent of the earth’ s crust, iron is one of the earths’most plentiful resources. Rainwater as it infiltrates the soil and underlying geologic formations dissolve iron, causing it to seep into aquifers that serve as sources of groundwater for wells. It also promotes the growth of Iron bacteria in the water. The

values of Fe2+ lies in the permissible limit as per BSI standard but its increasing trend may be due to the rusting of pipes which used for the irrigation of water from this Lake.

Chloride (Cl-): -

The chloride content in rainwater is usually less than 10 ppm. The chloride content of rainwater may be high in coastal areas this can be attributed to the high chloride content of ocean water to the order of about 13,000 ppm. Cl- is a natural substance present in potable water and usually occurring in sewage as metallic acid. The general source of chloride is animal organic matter, sewage from drainage and refuse. High concentrations may be injurious to people suffering from the disease of heart or kidney As per BIS (1991) the highest desirable value is 250 ppm and the maximum permissible limit for chloride in drinking water is 1000 ppm. However, a concentration above 100 ppm itself can cause physiological damage. The value of Cl- also lies within the permissible limit and shows an increasing trend.

Fluoride (Fl-): -Traces of fluorides are present in many glasses of water; higher concentrations are often associated with underground sources. The value of Fl- from 2017-18 period only available. This value lies within the specifications of drinking water.

Coliform Bacteria: -Escherichia coli is a common type of bacteria which lives in the intestine of animals and humans. The E-Coli content in water is a direct indication of contact of a sewage system or animal waste directly with the water body. As per the data obtained through RTI (2005) from the water authority of Sasthamcotta the about 1100+ E-Coli bacteria were identified and

counted in from a water sample of 2017. This large number of bacterial growths indicating an in the proper sewage system and contact with human and animal waste to the freshwater Lake. This will lead to causing diseases like diarrhea to the people who drink the water regularly.

Pollution:-

As per the report from the legislative environmental committee in (1992)1616 families living near the catchment areas of the Sasthamcotta Lake. Besides that, the committee understands that wastes dumping from nearest houses, markets, hospitals etc. It is identified that the dry areas of the Lake are largely used for agricultural purposes. It results in the soil erosion and reduces the depth of the Lake. Medias reported that a large level of pesticide uses in agricultural activities pollute the Lake water. A large scale of agricultural activities identified in the 13 Punnamoodu, Muthupilakkadu area. A Bund road connect with Muthupilakadu to west Kallada under the Indo-Norwegian plan for preventing the overflow of Lake water which destroys Peoples dump the wastes into the Lake from bund road. It can see every people in the bund road from Muthupilakadu to West Kallada. The local people's views that the area is used for some anti-social activities like alcohol. There was a case reported in 2017 is dumping of human excreta near Sasthamcotta Lake. Water pumping from Sasthamcotta Lake was disrupted in June 2018 due to the presence of Iron bacteria. A lot of vehicles have placed near the Lake are which is under the custody of Sasthamcotta police due to the cases of illegal mining and transporting.

Policy analysis:-

Former chief minister Sri. Oommen Chandy visited the Sasthamcotta and divide the responsibilities of protection measures to a different department.16.23 lakh rupees allocated for the action plan of conservation and management of Sasthamcotta wetland in the year of 2009-10. As per the report from district collectorate, the prohibition order declares against the activities which adversely affect in Sasthamcotta Lake in every two months in the catchment area. But the local people reveal that the declarations not only protect the Lake but need the active intervention. The soil conservation department also conducted a training programme for creating awareness among the community regarding the importance of the Lake as well as scientific soil and water conservation practices. The rule of banning construction activities in 50 meters distance from Sasthamcotta Lake implemented by Kerala state pollution control board and Mining and Geology department. But the human encroachment and construction activities are directly visible within this distance on the east side of the Lake. A lot of peoples living there without the proper land document. A project of planting trees in the catchment area of the Lake known as 'Harithatheeram' is initiated by Kollam district panchayat for protecting Sasthamcotta Lake. The main sight of the plan is to prevent the soil erosion, improve the abundance of water, ensure water purity etc. It is in the infant stage, not implemented yet. Sasthamcotta Grama Panchayat takes the initiative of planting trees through MGNREGP in the catchment areas of the Lake. But the fact is that there is no going management system for protection of planted trees. Because it has become a feed of cows in later and remaining will not grow. The planted trees under these schemes were dried and burned-out during summer season. Kerala State Bio-Diversity Board

took the initiatives of organizing biodiversity conservation committee including local peoples in Sasthamcotta, West Kallada, Mynagappally panchayats in 2014. The government of Kerala grants permission to this committee for undertaking duties of afforestation. They establish warning boards around the Lake area. As a coordination with district collectorate, they prohibit the ritual of Balitharpanam and waste deposition in the catchment area in order to prevent fish deterioration and water pollution which carried out in Sasthamcotta Lake. For the awareness of water protection at Sasthamcotta Lake, they conduct seminars and awareness classes in different wards of panchayats. Besides that, they prepare a biodiversity register based on the detailed study of different species depends on the Lake system. Sasthamcotta Lake protection council take a decision of cutting Acasia tees which consume a large amount of 14 water from Sasthamcotta Lake and placed with Pandanus (Kaitha) and Bamboos. But it's not implemented. The government of Kerala prepared a conservation and management action plan Map in 1990 for sustainable utilization and conservation of Lake Water. The state government sends the 24 crores 85 lakh rupees detailed proposal to the Ministry of Environment, Forest and climate change in 2013. The Union minister of Drinking water and sanitation visited by Sasthamcotta Lake on 10th June 2017 and understand the actual situation and ordered to the state water resource department to take immediate action. A police station, Munsiff magistrate Court, KunnathurTaluk office situated within 2 km from Sasthamcotta Lake. And yet the life of the Lake face serious challenges. The pipes imported for taking water from Kallada River in order to meet the water demand of people delayed due to the land acquisition case and the adverse effect of Mandrothuruth resulted in the perishing of pipes in Lakeshore. Peoples are concern about

contamination of iron from castrum pipe to Lake Water. The past experience and continuous deterioration prove the ineffectiveness policy from the government.

Allocation :- Expense wise categorization of different governmental departments The economic importance of the Lake is a quality water can buy with a minimum amount. If it is not having, they will pay a high amount for buying the quality water. The health cost of households and government if it is polluted and the additional expense of getting water from other places are the economic impact of the Lake pollution. A lot of funds allocated and expensed by a different state, central and local bodies in order to protect the Sasthamcotta Lake. The expenses include purchasing planting materials, installing tree guards, installation of warning boards, advertisement, administration expenses, inauguration, publicity awareness creation, seminars, tender etc. The revenue of 44 lakh received by the government with the sale of 5000 accused trees in the name of protection of the Lake. The promise of chief minister in state legislative assembly in 4th July 2004 17.50 crore The promise of the Ministry of Environment, forest and climatein 2011 4.92 crore. Coir Geotextile project in 2012(implemented) 15 lakhs. Cleaning of Sasthamcotta Lake by district panchayat (Budget allocation of 2011-12) 10 lakhs. KWA allocated fund to remove solid waste and weeds in the Lake. 3 crores. Central government allowance 3.13 crore. Eco-restoration of Sasthamcotta Lake through Swachitha mission. (implemented ongoing project) 171 lakh Sanitary complex (40) at Sasthamcotta and Bharanikkavu (work not commenced) 23,72,000. Biogas plant at Bharanikkavu (work ongoing) 4,77,500. Water quality monitoring (Ongoing through CUSAT) 6,70,000. IEC Campaign (Not commenced) 5,12,800. Central government grant to State fisheries management society for rejuvenating Lake fish. To building the check dam in Kallada River for taking water instead of Sasthamcotta Lake 19 crore Pumphouse and pipeline 14.5 crore.

Central fund to state 59 lakh 65thousand Source: data from various secondary sources Source: data from concerned authoritiesA lot of promises and announcements continue from the 1990s, but the desired result didn' t gets. A lot of funds are either misused or unused. The various projects and schemes are not yielded satisfactory results. Alternative sources of taking water from Kallada and Thenmala were established but not successful. The project for building check dam in Kallada river and pump house and pipeline for taking water is discarded in a midway due to the adverse effect of this plan in Mandrothuruth Island and a case of a land acquisition in that area. 5. Fights for protection The campaign done by Pallikal Bhavani, against the sand mining activities of west Kallada which affect the deterioration of Sasthamcotta Lake is the famous one in the history of protection of Sasthamcotta Lake. A master action plan prepared by a pure water protecting society constituted in 27 to December 1997 as District collector was the working chairman. A Lake protection Action council formed in 2004 by local people. A Writ petition filed by K Karunakaran Pillai to Hon' High court for the protection of the Lake. A Mass movement and picketing of CI office against mining activities of Kallada River done by West Kallada River.

The Pumphouse siege conducted by local people demanded protection of the Lake and resolve the issue of pure water scarcity of Sasthamcotta. The Programme of human chain around the Lake in 2008 was another historical event. The indefinite Satyagraha against the irresponsibility of the government towards Lake Protection started in 2010. A lot of peoples came into them irrespective of their political interest.

A mass strike conducted before the Kerala state legislative assembly. The one-day Satyagraha organized by Sasthamcotta Lake protection council in 6 the November 2012 near the pump house with the demand of protecting the remaining Lake water. A cultural fellowship organized near the

Lake in 2013 named 'Muravili' as a protest for the protection of the Lake. The major political parties support the strikes which for the protection of the entire Lake s. The fasting Satyagraha for this same intention done in 2013.People' s responses A sample survey conducted in Sasthamcotta for knowing the response of local people against the deterioration and pollution of the Lake. The entire Lake existed in three panchayats of Sasthamcotta, West Kallada, and Mynagapally. There are eleven wards have around the Sasthamcotta Lake. Within this six from Sasthamcotta, four from West Kallada, and one from Mynagapally. Within this majority of Lake Area exist in Sasthamcotta panchayath. There are ten places identified as the major catchment area of the Lake in Sasthamcotta panchayath. These are Venga, Aanjilimoodu, Kuthiramunamp, Rajagiri, and Sasthamcotta town, Ambalakkadavu, near college road, Muthupilakadu, Punnamoodu, and Peruvelikkara. A survey conducted in 90 households of selected catchment area.66 percent of peoples didn' t know that this Lake has come under the Ramsar site. It proves the failure of proper awareness programme implemented in the shore area. The day to day activities of the whole people who lived in the catchment area depends upon the Lake. It is the major drinking water source not only Sasthamcotta but in Kollam corporation. It brings down the temperature level in the summer season, provides pure air, scenic beauty, fishing etc. Usually, the fishing activities doing it by peoples of Manakkara area in Sasthamcotta. The local peoples do not directly take water from the Lake but it provides by KWA after the purification process. The important thing is that the peoples of Sasthamcotta face a pure water scarcity. The insufficient installation of water pipes connections in Sasthamcotta is the main reason. There is only one pipe has in Punnamoodu area. The women' s carry bucket of water from that pipe and often they arise conflict for water sharing. The question arises in this situation is that who are the original beneficiaries of the Lake for protecting. Some of them received a

monetary benefit from panchayath for construct the sidewall of the house which prevents the soil erosion and an assistance from Lake Protection office in Sasthamcotta. The majority of peoples who live near the catchment area have no proper land records and proper waste management facilities. That's why they do not get any benefit from government. The water deterioration also affected the fishing activities of local peoples. They shift their operation into other water bodies due to the declining fish population and drying up of the Lake. The Census of the fish population in Sasthamcotta Lake done by the Department of Aquatic biology associated with Kerala state council for science, Technology and environment and Indian science congress identified the down of 17 species of fish under-recorded diversity out of 30 in the Lake. Kerala Conservation of Paddy and Wetland Act, 2008 impose the restrictions of clay mining activities. The strict police patrolling and government rules of preventing mining activities around the area of Sasthamcotta resulted in the closing down of a lot of bricks industries. Which create a problem of unemployment 17 and economic crises of local peoples. The wastewater from the pump house going to the Lake. The peoples respond that the clay and sand mining from Cheloor Lake is largely affected by the deterioration of the Lake. In their views, the current protesters are not the actual one but they exist only for monetary benefit. The speeches did not give any output but need the action. Now everything is on paper only. The unscientific removal of acacia trees did not give any positive impact in Sasthamcotta Lake. Becuase, they cut the tree with bark, not from root. Its root reaches the groundwater level and absorbs water. Due to the ineffective implementation of protective measures of the Lake, local peoples not ready to pay any amount for protection of the Lake. They already pay 48 rupees per month as a minimum for getting water from KWA. They are not ready to receive water from other alternative sources. The image of pure water in Sasthamcotta Lake

largely depends upon their preference. Besides that, they have a short-term experience of using water from Kallada River through Kallada Irrigation project when identifying the presence of Iron bacteria in Lake Water. The Lake did not provide any employment opportunity to the local peoples now. The small waves of Lake Reach the wastes in Lake Shore in the earlier period, but now it's not possible due to the dry up of Lake Water. Majority of them have no prospects of Sasthamcotta Lake which can be revived in the past glory.No governmental authority monitoring the catchment area for preventing pollution and managing plants which planted under various government schemes and nongovernmental agencies. The peoples who lived near the catchment area have no other way of living whether they have any other choice they should prefer other comfort areas. According to them the poor people' s only try to live near the Lakeshore, sea shore etc. In the words of Lake Champions, the illegal Lake acquisition, agricultural activities of Lakeshore and their pesticide uses, building constructions of past sixty years destroy the entire Lake. In 2010 the catchment area marked by the government. It helps the invaders to acquire the remaining outside marked land.

Feasibility of Tourism The book of Destination wetlands: supporting sustainable tourism published jointly by Ramsar and UN WTO which provide an overview of sustainable tourism in the wetland area. It shows the need to manage wetland through sound policies, awareness raising, and planning. It points out that the tourism activities conserve native wetlands and poverty alleviation through improvement of livelihood and save the local cultural heritage. But the possibility of pollution when tourism arrives is a great challenge in Sasthamcotta Lake.

Rejuvenation methods: - Preventive and ameliorative methods can be widely used for Lake Restoration. The first one is used for identifying the pollutant and reduce its generation and later means treatment of waste before discharge. The diversion of waste system is frequently used in eutrophic Lake which have dominated algae. Recently Sasthamcotta Lake has an increasing amount of algae. It prevents the local peoples to directly use the Lake water. Due to the excessive nutrients especially nitrogen and phosphorus support the growth of these algae. The sewage effluence is the main source of affluence. This method was successfully tried in Lake Washington in Washington State. This diversion improves species diversity, increase bottom oxygen, decrease in phytoplankton biomass and reduce the concentration of nutrients. The techniques used by Lake Balton, in Hungary is the best example for Sasthamcotta. They implement the strict measures like limiting Lake Water to drinking water and recreation, Prohibit of all treated and untreated wastewater effluence, Permitting no new industries in the Lake Catchment, etc. Sediment removal using conventional hydraulic dredges during the summer season are commonly used techniques for reducing internal cycling of nutrient, increase the groundwater inflow.

This may be applicable in Sasthamcotta after the environmental impact study with a credible agency. Rose (1977) pointing out the increasing groundwater level after dredging in Wisconsin. Bhoj wetland in Madhya Pradesh which is also a Ramsar site with rich biodiversity is an example of drudging for improving water quality. In the Lake, biological methods like species manipulation are mainly used for

Lake Restoration: - Pictorial representation of suggesting rejuvenations methods.

1: Rain pits to collect water.

2: Grass plantation around the pits to avoid land slide.

3: Mangrove belt for avoid soil erosion and provide a good ecosystem.

4: percolation of stored water in rain pits through the aquifers of hills.

5: A barrier structure to prevent soil erosion

6: Lake Water.

7: Removal of deposited sediments through soil erosion and opens natural spring.

8: Dried portion of the lake.

9: Sasthamcotta Lake an outline.

10: Bund road

11: Waste fly off prevention by protection net.

12: Area of paddy field.

CONCLUSION:

- Results obtained from the present study shall be useful in future management of the Sasthamcotta Lake. COD, BOD, pH, and turbidity of the water samples were exceeding the desirable limit. Butthisstudy observed that, there are fluctuations during months. The other physico chemical parameters such as EC, TDS, DO, calcium, magnesium, total hardness, calcium hardness, chlorides andsulphates were within desirable limits during entire study period. All the sampling points were bacteriologically contaminated. So, quality of lake was poor andis not suitable for drinking, washing,bathingandother recreational purposes. Studies carried out in present investigation revealed that one of the most important causes of water pollution is unplanned town developmentwithout adequate attention to suitable management of waste material. The presentstudy recommended thatmeasures for the prevention of this contamination should be taken. Microbial contamination was detected in all samples, which is a serious threat to human health. So, thisproblem should be considered seriously. Government andother responsible authorities of Sasthamcotta should take measures to protect Sasthamcotta Lake and to provide safe drinking water. A comprehensive public awareness programme is to be conducted to improve the aesthetic environment near the lake

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