# GEOSTATISTICAL MODELLING OF SEDIMENT CHEMISTRY OF ASHTAMUDI LAKE USING GIS AND STUDY THE CHANGE DURING PAST SEVERAL YEARS

**Grace K Mikhayel[1], Prof .Chinnamma[2]**

*Malabar College of Engineering and Technology, Kerala Technology University, Thrissur (Dist),Kerala,India*

## *Abstract*

*Water is valuable natural resources that essential to human survive and the ecosystems health. Water are comprises of coastal water bodies and fresh water bodies (lakes, river and groundwater). Since the past few decades, the increasing of anthropogenic activities especially in industrial area has effects to water bodies. This is the global issues which happening throughout the world and Kerala also face these problems. This study attempts to show the spatial distribution of sediment chemical parameters in the Ashtamudi Lake, Kollam and study the change during several past years. It also shows the partitioning of heavy metals in lake water. The Ashtamudi Lake is the second largest wetland ecosystem in Kerala. The lake is polluted by nearby factories, oil mills, boats, septic wastes etc. Sediment play an important role in elemental cycling in the aquatic environment and can be a sensitive indicator for monitoring contaminants in aquatic environment. GIS and remote sensing techniques can be used to make effective maps showing the effective spatial distribution of each parameters. Also sediment samples from various sample locations of Ashtamudi Lake will be collected and testing will be done accordingly.*

**Index Term-*Ashtamudi lake[1], sediment sample[2], sample point[3], sample location[4],parameters[5]***

## 1. INTRODUCTION

Water is valuable natural resources that essential to human survive and the ecosystems health. Water are comprises of coastal water bodies and fresh water bodies (lakes, river and groundwater). Since the past few decades, the increasing of anthropogenic activities especially in industrial area has effects to water bodies. This is the global issues which happening throughout the world and Kerala also face these problems. Today, with the advancement of science and technology, the population, industries, agriculture activities, and urban developments have grown up along the corridor or riverbanks of Kerala. The domestic's sewage, factories effluents, and agriculture waste can lead to deterioration of river water quality. Because of that the river water quality monitoring program are needed in order to raise awareness of public by address the consequences of present and future threats of contamination to water resources. The characteristic of water can be categorized into three namely physical, biological and chemical. These characteristics are used in water monitoring program. Thus, the technologies such as remote sensing and GIS are very useful as a tool in evaluating and monitoring water quality.

A lake may be defined as an enclosed body of water (usually freshwater) totally surrounded by land and with no direct access to the sea. A lake may also be isolated, with no observable

direct water input and, on occasions, no direct output. In many circumstances these isolated lakes are saline due to evaporation or groundwater inputs. Depending on its origin, a lake may occur anywhere within a river basin. A headwater lake has no single river input but is maintained by inflow from many small tributary streams, by direct surface rainfall and by groundwater inflow.

Such lakes almost invariably have a single river output. Further downstream in river basins, lakes have a major input and one major output, with the water balance from input to output varying as a function of additional sources of water.

Kerala is well known for brackish water systems, once mangroves were really a part of it and now facing the verge of extinction. Not only the mangroves but also thousands of unique and mutually related faunal aspects may also perish in the nearby feature if not conserved properly. The „*Ashtamudi'* is one of the largest wetland ecosystems in Kerala. This estuarine system lies in Kollam district and is the second largest wet land of the state. It is a palm shaped extensive water body with eight prominent arms, adjoining the Kollam Town. The arms converge into a single outlet at Neendakara, to enter the Lakshadweep Sea. This estuary is the deepest among all the estuaries of Kerala with a maximum depth of 6.4 m at the confluence zone. The major river discharging into the *Ashtamudi* is the *Kallada* river which originates from the Western Ghats and travels around 120 Km. *Ashtamudi* lake has been designated as RAMSAR SITE in November 2002. 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 fundamental human needs for water are for drinking, cooking and personal sanitation.

## 2. MATERIALS AND METHODS

### a) STUDY AREA

***Ashtamudi Lake***

Ashtamudi lake located in the Kollam district is the second largest esturine system in kerala with a water spread area of about 32 $Km^2$. The lake is located between latitude 853'-9C,N and longitude 7631'-7641'E. The main basin is approximately 13km long and the width varies from a few 100 meters to about 3 km. It is a palm shaped extensive water body with eight prominent arms, adjoining the kollam town. The major river discharging is the Kallada river, originating from the Western Ghats have an annual discharge of 75 × 109 $m^3$ of water in to the Ashtamudi lake. It is formed by the confluence of three rivers, viz., the Kulathupuzha, the Chendurni and Kalthurthy. The lake opens to the Arabian sea at Neendakara, Southwest coast of India. Several major and minor drainage channels loaded with waste products from municipal and industrial sources join the lake at southern end. Cocunut husk retting for coir fiber manufacture is predominant at several locations in the eastern arms of this estuary. The lake is the deepest among all estuaries of Kerala with a maximum depth of 6.4 km at the confluence zone.

Five station points at various locations are selected and at each location three sampling points are selected. From these sampling points 500gm of sediment samples are collected, chosen for sediment analysis and study of pollutant effects. Fig 3.1.1 shows the sampling stations ie, Munroe island, Kundara, Chavara, Kureepuzha ans Neendakara. Table 3.1 and 3.2 shows the detailed list of sampling stations and sampling points.

**b) Locations**

**(i) *Munroe Island***

Munroe Island (Munroethuruth) is a cluster of eight tiny islands in Ashtamudi Lake. Chavara South, a small village, an island within the Ashtamudi Lake, located 14 km (8.7 mi) away from Quilon on the National Highway NH 47, is reported to be mineral rich with number of factories for extraction and export of titanium and other minerals. Effluent from the factories is reported to be causing pollution of the lake waters. Thekkumbhagom Island, situated on the bank of the Ashtamudi Lake, provides an enchanting natural beauty and also feel of rustic life of a village.

**(ii) Kundara**

Kundara is situated 13 km east of Kollam city, 14 km west of Kottarakkara and 24 km north of Paravur. Kundara is significant for its historic involvement in the Indian independence movement. Kundara was once the industrial hub of Southern Kerala, which was the home to prominent industrial companies including Kerala Electricals Limited, the Aluminium Industry Limited of Kundara, and the Lakshmi Starch company. Many of these companies have since failed and Kundara is attempting to revive this industrial tradition by developing Technopark Kollam.

Kundara is located on the shores of Kanjiracode Lake, a branch of Ashtamudi Lake which has one of the finestquality Greenchromide (Karimeen) fish available in India. This lake recently received Marine Stewardship council recognition for sustainable fishing.

**(iii) *Chavara***

Kerala Minerals and Metals Ltd is an integrated titanium dioxide manufacturing public sector undertaking in Kollam, Kerala, India. Its operations comprise mining, mineral separation, synthetic rutile and pigment-production plants. Apart from producing rutile-grade titanium dioxide pigment for various types of industries, it also produces other products like ilmenite, rutile, zircon, sillimanite, synthetic rutile etc. It is one of the best performing Public Sector Units in India. The company manufactures titanium dioxide through the chloride route. The different grades are produced by KMML under the brand name KEMOX. KMML has always been responsive to social and environmental causes. Some of the initiatives taken by KMML have made a significant change to the area and its people.

**(iv) *Kureepuzha***

Kureepuzha is a zone and neighbourhood situated at the coastal area of the city of Kollam in Kerala India. It is one among the 6 zonal headquart Sakthikulangara is situated where Ashtamudi Lake confluence with the Arabian Sea. It is 7 km north from the core Kollam City and 31 km away from Paravur town. Heading from North Neendakara bridge opens the entrance to Sakthikulangara villageers of Kollam Municipal Corporation

**(v) *Neendakara***

Neendakara area is the most polluted region of Ashtamudi Lake. Neendakara area where the lake receives maximum disposal of wastes like hotel waste, plastic materials, wash water from household, markets, discharge from house boats. Upstream stream side of Neendakara is Kureepuzha where Kollam City’s waste management plant is situated Kerala's only turkey farm and a regional poultry farm are at Kureepuzha. The waste produced at Kollam Corporation was collected from various localities and was dumped at Kureepuzha waste dumping site. It consists of disposal mainly from wash water of transport depot, hydrocarbons from boats, hotel wastes, markets, house hold wastes, commercial wastes.

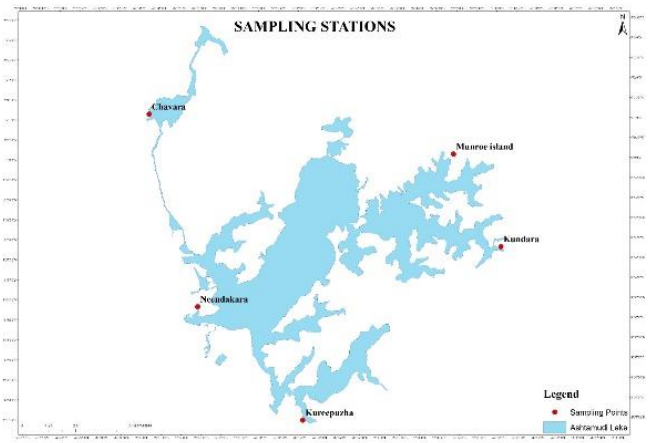
**Table 1: Sampling stations of Ashtamudi Lake with latitudes and longitudes**

| LOCATIONS | STATIONS | LONGITUDE (degree) | LATITUDE (degree) |
|---|---|---|---|
| MUNROE ISLAND | S1 | 76.648142 | 9.001762 |
| | S2 | 76.633056 | 8.998023 |
| | S3 | 76.657775 | 8.983559 |
| KUNDARA | S1 | 76.667958 | 8.963004 |
| | S2 | 76.66258 | 8.966098 |
| | S3 | 76.658847 | 8.954776 |
| CHAVARA | S1 | 76.522076 | 9.018167 |
| | S2 | 76.623016 | 9.023266 |
| | S3 | 76.623435 | 9.015509 |
| KUREEPUZHA | S1 | 76.684425 | 8.890988 |
| | S2 | 76.687262 | 8.889626 |
| | S3 | 76.683876 | 8.89432 |
| NEENDAKARA | S1 | 76.540494 | 8.93848 |
| | S2 | 76.637632 | 8.931167 |
| | S3 | 76.64787 | 8.930933 |

**c) ArcGIS**

ArcGIS 10.3.1 is used in this project to show geochemical indices and spatially explain the contaminated areas in the form of interpolated maps. ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community and openly on the Web. ArcGIS server is the core server geographic information system software made by Esri. ArcGIS server is used for creating and managing GIS Web services, applications and data. ArcGIS server is typically deployed on-premises with in the organization's service-oriented architecture or off-premises in a cloud computing environment. ArcGIS server ships in three functional editions, Basic, Standard and Advanced, with the advanced edition providing the most functionality.

**Fig: 1 MAP SHOWING THE SAMPLING STATIONS**



## d)CHANGES TO THE ASHTAMUDI LAKE

The Esturine eco-systems in india are the most critical component of the coastal environment as it sustains millions of people and implications of its degradation is disastrous. The Ashtamudi lake in Kollam District is one of the deepest and largest wetland ecosystems of Kerala State. The shores of Ashtamudi Lake are home to thousands of Kollam district's population. The lake plays a vital role in the socio-economic and cultural history of the State besides constituting an invaluable aesthetic resource. The rapid growth of Kollam city due to establishment of new Government offices and industrial projects (Neendakara port and Titanium Complex projects) have increased the pollution load on the Ashtamudi Lake.

## DEGRADATION OF ASHTAMUDI LAKE

The water quality of Ashtamudi Lake is deteriorating specifically in the reach joining the site with built up area of Kollam city, TS Canal and Kallada River. It currently receives all untreated sewage from the Kollam city, direct disposal of human excreta from hanging latrines and household waste. The fore shore areas of this Lake are reclaimed for coconut plantation and construction purposes resulting in the shrinkage of lake. The microbial contamination is high in some locations particularly around the port area and in the Kallada River zone. The agricultural practices warrant the use of chemical/organic fertilizers and insecticides/pesticides and the residual flow in to the lake causing pollution and Water Eutrophication. The southern portion of Ashtamudi Lake is affected by waste disposal from the coconut husk retting, Ceramic, Paper and palm oil industries, tourism activities, Cashew factories and hospitals which resulted in the increase of bioaccumulation of sediments and heavy metals. The untreated effluents from small-scale industries, unscientific methods of fishing, food processing units, boat building yards, oil spillage and slaughter houses makes the situation even worse. The water quality parameters are analysed for DO, pH and heavy metals over a period of 10 years and it was found that the quality of water in Ashtamudi Lake is deteriorating at faster rate. The Kerala State Council for Science Technology and Environment (KSCSTE) has suggested a comprehensive plan to improve the water quality and sustainability of Ashtamudi Lake.

Following are the reasons for the deterioration of water quality parameters in Astmaudi Lake.

### (a) Reclamation of Ashtamudi Lake:

The human interventions during the past years have resulted in reduction of water spread area in Ashtamudi Lake. The lake is reclaimed for various purposes like agricultural expansion, agricultural practices, coir retting, harbour development, urban development and other public and private uses. Dumping of urban wastes is also reclaiming South end of the Ashtamudi Lake near the Asramam region. Most of the reclamations are for agricultural, housing and paddy cusm shrimp culture cultivation. The islands being enlarged in the entrance zone using sands, dredged from the national Waterway (NW-3) channel, which in turn is diverting the main flow and changing the flushing characteristics of southern and central portion of Ashtamudi Lake. It has been reported that the dumping from the clay mines has reclaimed about 3 $Km^2$ of estuary during 25 years. The waste disposal of coconut pith is having a major impact on bottom sediments and results in reduction of Dissolved Oxygen, which impacts negatively on fish and overall health of waterbody. The coir retting also causes organic pollution of the lake, resulting in release of large quantities of organic substances like pectin, fat and tannin into the water by activity of bacteria and fungi. The decomposition of pectin results in the production of hydrogen sulphides producing nauseating smell in and around retting zones. A high organic content (6%-3%), high BOD 10mg/l (safe limit 3 mg/l), low oxygen 0.05 mg/l (safe limit 4 mg/l) and high sulphide (4.97 mg/l) characteristic are found near the retting zones of ashtamudi Lake, which is affecting the flora and fauna of the lake.

**(b) Industrial Pollution:**

The Ashtamudi region is well end owed with natural resources (eg. rare earths, clays, raw product) and lake's vicinity with Kollam city (eg. connections to highways, waterways, fishing port facilities) have resulted faster industrial growth. The major industries which release effluents to Ashtamudi lake are Kundara Ceramics (clay products), Indian Rare Earths Ltd (mineral extraction), Kerala Metals and Minerals Ltd (mineral extraction), Kerala State Cashew Development Corporation Limited, Aluminium Industries Kundara etc. in addition to this there are many small scaleunits like fish processing, seafood units, motor and welding workshops functioning adjacent to the lake area. These effluents contain a large number of toxic ingrediants such as acids, alkali, heavy metals, suspended solids and number of other chemicls, which have immediate and long term effects on the organisms.

**(c) Water Transport:**

The 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 Asjtamudi lake. The Water Transport Department operate regular boat services to Muthiraparamb (West Kllada), Ayiramthengu, Munroethuruthu and Alappuzha. Incidents of poor handling offuel have led to oil spillage 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(p.Anoop et al,2007).

**(d) Tourism:**

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 Munrothuruthu and towards north up to Alappuzha. Speedboats operate in Asramam kayal, which is the Southern part of Ashtamudi Lake. The unimpeded tourism activities contribute significantly to pollution, which has accelerated water eutrophication, encroachment, reclamation, mining and biodiversity loss.

(e) **Sand Mining**:

Sand mining is presently conducted in the Kallada River zone and along the northern shore of Ashtamudi lake. The sand mining activity will lead to deepening of the river bed, 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 in filling 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.

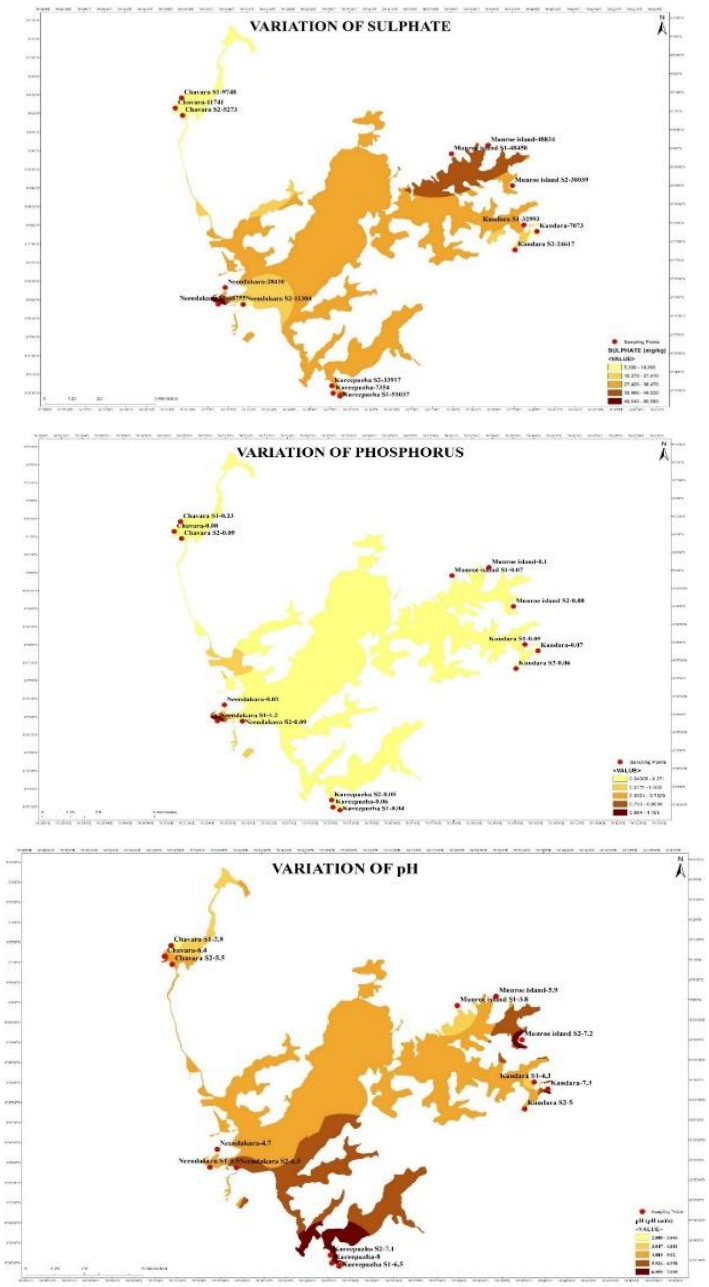
**(f) Municipal Waste Disposal:**

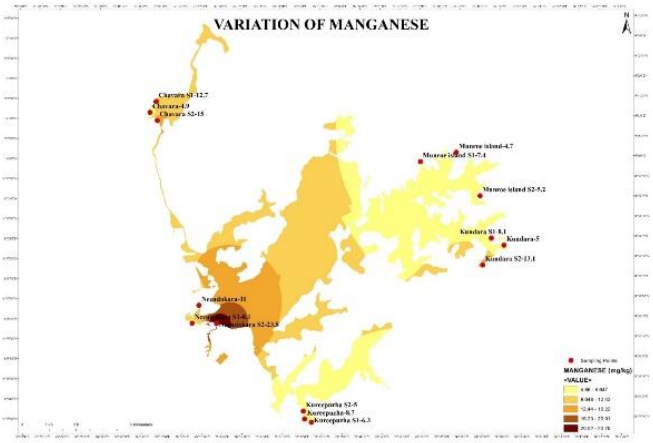
Municipal solid waste and sewage from Kollam Municipal Corporation are one of the major sources for lake pollutionas it uses the Ashtamudi Lake as a"water sink". It is estimated that the laterines of about 60% of houses near the lake are directly discharging in to the lake. Unfortunately the waste dumping yard of Kollam Municipal Corporation is also located very close to the banks of Southern Kayal 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 is no proper management practices for disposing the waste from slaughter house and hospital in the city.

## 3. RESULTS AND DISCUSSIONS

The natural water sources are polluted by various means. The main sources of pollution are natural agricultural, mining, municipal, industrial etc. discharge of untreated or partially treated sewage in water bodies as common practice followed by means of municipalities, is one of the most primary sources of water pollution, especially near big cities. Due to this the properties of water get changed and the minerals are deposited on these sources. The variations are analyzed at various stations which is described below. Various parameters like electrical conductivity, BOD, pH, iron, manganese, zinc etc., were determined. The table shows the results of the above mentioned parameters at various stations.

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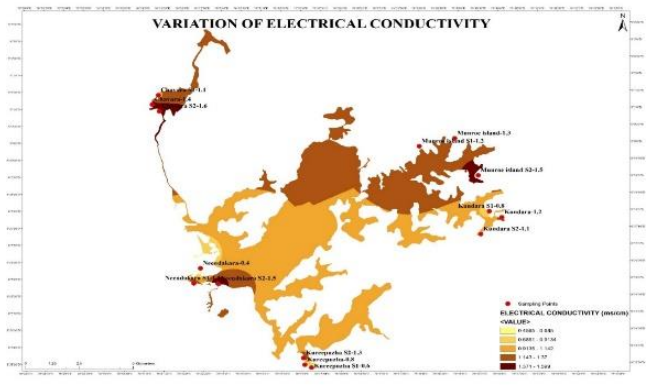
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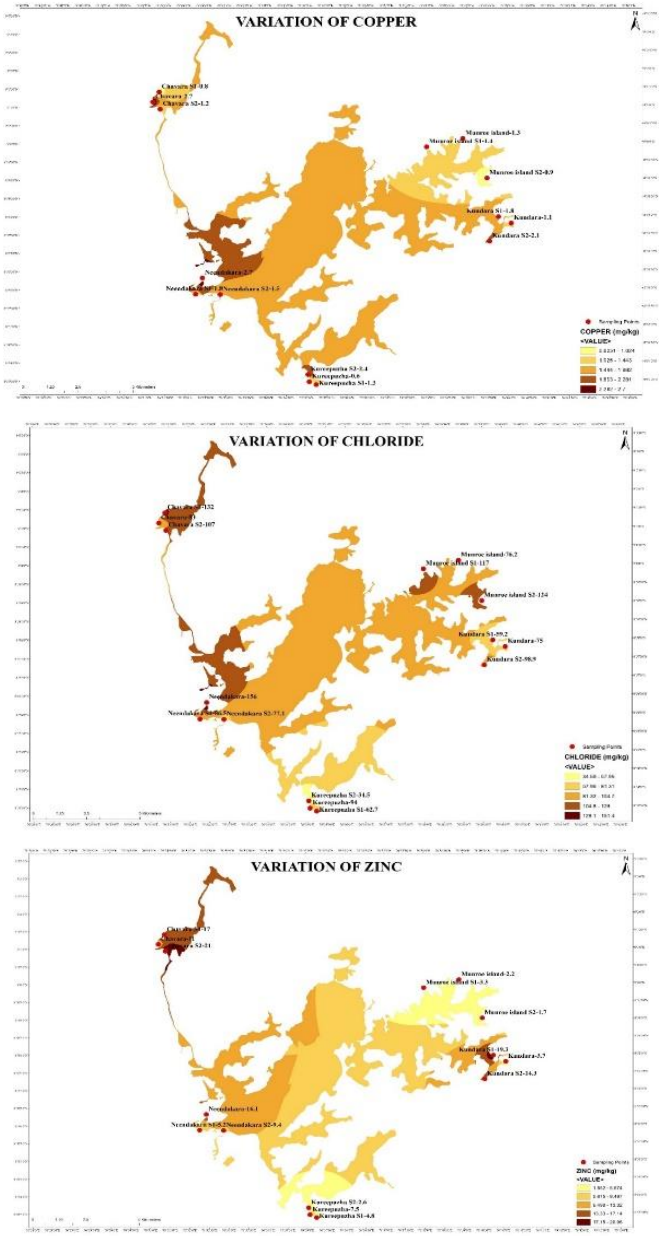


## DISCUSSIONS OF RESULTS

The samples were collected from fifteen sampling points of five locations and various parameters are determined. From the study sulphate is more observed at Munroe Island. From graph 4.11e content is 45107.66mg/l which is very higher than the permissible limit 100mg/l (Table 3.5.2). This may be because of the presence of small scale industries at this station. Chloride, copper and iron is more at Kundara station, which is 203.1mg/l, 5 mg/l and 522 mg/l respectively. Chloride is below than the permissible limit 1000mg/l. Copper 5mg/l higher than the 1.5 mg/l permissible limit. Iron content 522 mg/l which is very much higher than the permissible limit 1mg/l. the rapid increase of iron content is because of Kundara Ceramics, Indian rre earth Ltd, Kerala State Cashew Development Corporation Limited, Aluminium Industries which is located near the stations and they direct discharge effluents to the lake water. Lead content is more at Kureepuzha station is 3.233 mg/l from graph 4.7. The permissible limit is 0.1 mg/l. the lead content causes damage to the central and peripheral nervous system, learning disabilities etc.

## IV. CONCLUSIONS

This study attempts to show the chemical parameters of the sediment in the Ashtamudi Lake and changes occur during several past years. Five sampling stations were selected Munroe Island, Kundara, Chavara, Kureepuzha and Neendakara. At each station's three sampling points were selected and samples from these stations were collected and analyzed. Electrical conductivity, BOD, pH, Iron, Phosphorus, chloride sulphate etc were determined. From the study, sulphate and electrical conductivity is more at Munroe Island. Chloride, Copper and Iron is more observed at Kundara sampling station. Zinc, Manganese and BOD are more observed at Chavara. pH and Lead are more observed at Kureepuzha station. Phosphorus is more observed at Neendakara sampling station.

The water quality parameters are analysed for pH and heavy metals and it was found that the quality of water in Ashtamudi Lake is deteriorating at faster rate. The rapid growth of Kollam city due to establishment of new Government offices and industrial projects (Neendakara port and Titanium Complex projects) have increased the pollution load on the Ashtamudi Lake. The fore shore areas of this Lake are reclaimed for coconut plantation and construction purposes resulting in the shrinkage of lake. The microbial contamination is high in some locations particularly around the port area and in the Kallada River zone. Dumping of urban wastes is also reclaiming South end of the Ashtamudi Lake near the Asramam region. Most of the reclamations are for agricultural, housing and paddy cusm shrimp culture cultivation. It has been reported that the dumping from the clay mines has reclaimed about 3 $Km^2$ of estuary during 25 years. The waste disposal of coconut pith is having a major impact on bottom sediments and results in reduction of Dissolved Oxygen, which impacts negatively on fish and overall health of waterbody. Many industries and factories are located near the lake and they directly discharge effluents to the lake. These effluents contain a large number of toxic ingrediants such as acids, alkali, heavy metals, suspended solids and number of other chemicls, which have immediate and long term effects on the organisms.

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***Grace K Mikhayel*** *received B.tech degree in civil engineering from Sree Narayana Institute of Technology, in 2016 and currently pursing M.tech environmental engineering from Malabar College of Engineering and Technology.*