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On 18th February 2015

Organized by

Department of Chemistry, Easwari Engineering College (SRM Group of Institutions), Chennai-600089, India.

The Geochemistry of Poondi Reservoir, Tiruvallur District, Tamilnadu, India

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ABSTRACT: The study of the trace metals and heavy metals present in the Poondi reservoir plays a vital role in determining the extent of pollution in the study area. Overexploitation of nature and uncontrolled use of natural resources, including inadequate processing of industrial wastes have caused large contamination of world ecosystems by toxic metals which generally show considerable accumulation in aquatic sediments. .The present study deals with the impact of pollution on the five different sampling sites in and around the Poondi reservoir.The results of the assessment reveals the effect of this sediment bed in polluting the river Kortalaiyar which flows through Poondi reservoir collecting the pollutants along its flow. The Pearson's correlation matrix reveals the correlation between various metals indicating their proximity in origin and their distribution pattern.

KEYWORDS: Trace metals, Heavy metals, River Kortalaiyar, sediments, Pearson's correlation matrix.

I. INTRODUCTION

Lakes form an integral part of the River system. They are unique habitats of freshwater that store large amounts of water and trap suspended sediments delivered by rivers flowing into it. As integrators and collectors within their sub-basins, lakes provide an opportunity to study the entry of contaminants and transportation within a river system on a watershed by watershed basis.

Years of point and non-point source discharges from industrial and municipal facilities, and urban and agricultural runoff to the Poondi Lake and its tributaries have contributed toxic substances into the ecosystem, resulting in the major issues of contamination. In most cases, the contamination is introduced in the tributaries which, via sediment transport and erosion mechanisms, contribute to contamination of the lake. Because of their vast size and volume, less than 1% of the lake waters (averaged across the basin) are flushed annually, resulting in settling out and accumulation of suspended particle-associated contaminants in the water column. Hence, the sediments serve as repositories for and on-going sources of organic and inorganic contaminants, exposing and impacting aquatic organisms, wildlife and humans through the development of cancerous tumors, loss of suitable habitats and toxicity, fish consumption advisories, closed commercial fisheries, and restrictions on navigational dredging.

Metals in aquatic environments are increasingly recognized as important intermediate sources for subsequent pollution in aquatic ecosystems or public health. After being released from natural background or anthropogenic sources near the land surface, e.g., rivers carrying significant metal loadings, soluble heavy metal species are immobilized and deposited onto the sediment surfaces through various mechanisms[1].These immobilization mechanisms include adsorption onto soil/sediments by ion exchange, coagulation with dissolved or suspended species in water (organic matter), incorporation into the lattice structure of minerals, and precipitation by forming insoluble species of heavy metals [2]. The determination of the total concentrations of metals in sediments is not sufficient to be able to predict the capacity for mobilization of these elements. The environmental behavior of trace metals is critically dependent on their chemical

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form, that which influences mobility, bioavailability and toxicity to marine organisms [3]. Certain anthropogenic activity significantly decrease the water quality and increases the ecological risk to human health [4].

II. AIM AND OBJECTIVE

Poondi Lake acts as a reservoir to collect the water from the incoming sources and to pass it on to the Kortalaiyar River. Thus it is a part of the River. Kortalaiyar river is the source of fresh water to the Chennai metropolitan especially Tiruvallur district. The objective of the present work is to study the geochemistry of Poondi reservoir.The study enables the assessment of the pollution level in the study area. Further the correlation between the various metals present in the reservoir is studied. The sources of the pollutants are also determined in this study.The evaluation of the contaminants and the contamination sources can serve as a useful tool to propose the control and management of the Pollution in the Poondi reservoir.

III. STUDY AREA

The study area for the present work is five sampling sites in and around the Poondi reservoir.The geographical location can be indicated by the latitude and the longitude listed in Table-1.The sampling sites are as shown in fig-1

Sample no	Latitude	Longitude
1	13° 8'51.48“N	79°48'57.45"E
2	13° 9'22.25"N	79°48'43.12"E
3	13°12'41.03"N	79°52'10.18"E
4	13°13'43.57"N	79°53'37.50"E
5	13°13'10.12"N	79°54'4.76"E

Table-1

Fig-1

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IV. SEDIMENT SAMPLING AND ANALYSIS

Five samples of surface sediments were collected in an air dried Zip Lock covers for each season, Pre-Monsoon (PRM) and Post-Monsoon (POM) of two consecutive years from August 2011 to August 2013. The geographical locations of the sampling stations were marked using a Garmin eTrex hand-held GPS. The samples were collected from the surface of the river. The collected samples were tightly sealed in a zip lock cover and labeled before adopting laboratory geochemical analysis. The samples were dried in air and then powdered using an agate mortar. The powdered samples were sieved for further analysis [5].

V. RESULTS AND DISCUSSIONS

The Poondi reservoir was examined to contain Sodium, Aluminium, Silicon, Nitrogen, Phosphorous, Potassium, Boron, Barium, Calcium, Magnesium, Chromium, Nickel, Copper, Manganese, Iron, Zinc, and Titanium. The concentration of the metals is found to vary with seasons namely PRM and POM.

The fertility as well as biodiversity of an aquatic system is greatly influenced by the concentration of nitrogen in the sediment. It is one of the critical limiting factors to algal growth and Eutrophication in the water bodies. In the present study the concentration of Nitrogen 167 mg/g to 495 mg/g. The high nitrogen value during monsoon might be due to the dissipation from agricultural runoff and also due to low adhesion of nitrates to inorganic contents of sediments [6].The concentration of total nitrogen was the highest during PRM in site 3 which has a high concentration of 470 mg/g which could be attributed to oxidation of organic matter which has settled on the top layer of sediment [7].

Phosphorous is the second key nutrient found in the soil. Phosphorous content in the water of aquatic systems is greatly influenced by the bottom sediments. Sediments often play an important role in the uptake, storage and release of dissolved inorganic phosphorous in aquatic systems [8]. The concentration of Phosphorous in the present study varies between 172 mg/g to 199 mg/g .Addition of fertilizers from agricultural runoff, sewage contaminated storm water out falls and other anthropogenic activities such as use of detergents, bathing; cattle wading etc. contribute to high levels of phosphate in river sediments. The discharge of industrial effluents and the deposition of insoluble chemicals at the bottom of water increase the values of different nutrient parameters in the canal sediments.

Potassium is yet another major nutrient required for plant growth apart from nitrogen and phosphorous. The concentration of potassium in the study area ranges from 273mg/g to 394 mg/g. Lower values of potassium were observed in PRM compared to POM.

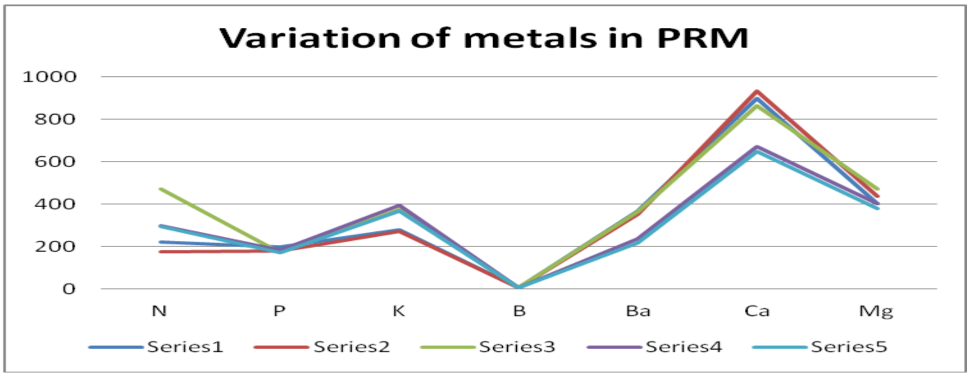

Fig-2

Boron is present in a very low concentration from 4.6 mg/g to 6.8 mg/g.The concentration of Boron is slightly higher in PRM than POM.Boron is a non metallic element ubiquitous in the environment ,existing naturally about 80 minerals[9]

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. Barium ,Calcium and Magnesium in the sediment is in high concentrations.The concentration of Barium varies from 203mg/g to 369mg/g.Calcium has a very high concentration of 932.6mg/g in site-2 and the least in site 5 with a concentration of 648.9mg/g in PRM.The concentration of Magnesium varies from 386.1mg/g to 473.1 mg/g.

The variation of the various major metals like Nitrogen,Phosphorous,Potassium, Boron, Barium, Calcium and Magnesium in the five different sampling site is shown in Fig-2 for PRM and Fig-3 for POM.The concentration of the metals is in mg/g.

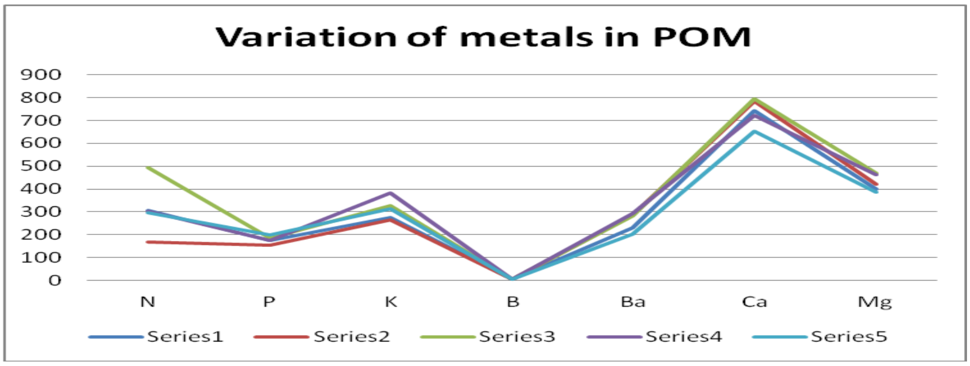

Fig.3

The heavy metals present in the lake is of great importance as they contribute to the toxicity of the study area. The problem is not restricted to soils with high metal levels, such as those of mining areas, as well as includes those with moderate to low metal contamination [10]. Heavy metal residues in contaminated habitats may accumulate in microorganisms like aquatic flora and fauna, which may enter into the human through food chain transfer and result in health problems [11]. The change in environmental conditions such as pH, redox potential, naturally organic matters and sediment texture may affect their mobilization of metals from sediments [12].The heavy metals detected in the lake is Chromium, Nickel, Copper, Manganese, Iron, Zinc and Titanium.

The variation of Chromium in PRM and POM in the five sites is depicted in fig.4.In PRM; Cr is present in a lower concentration in site 1 and highest concentration in site 5.

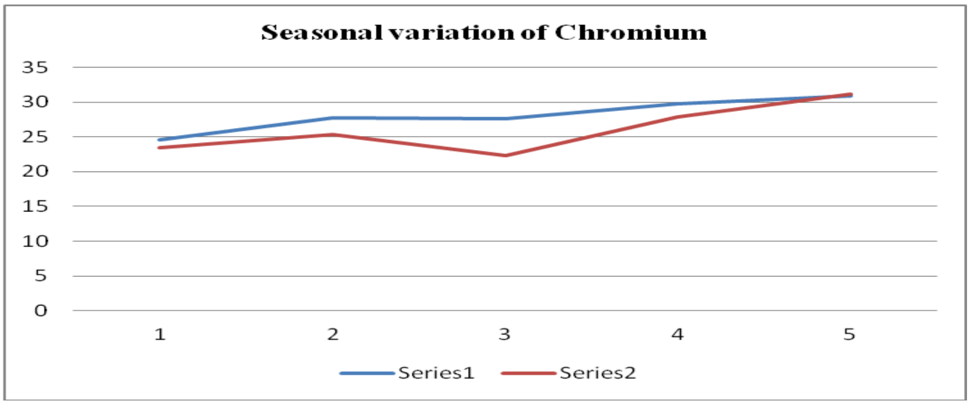

Fig.4

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In POM the minimum concentration is in site 3 and maximum in site5.The maximum concentration of Cr in the study is 31.2 mg/g. The observed Cr concentration is very high due to lithogenic sources, industrial wastages and anthropogenic activities. Cr is usually found naturally in rocks, soil, plants, and animals, including human beings [13]. Chromium does not degrade and cannot be destroyed. It goes on accumulating in due course of time. The high concentration of Cr is mainly attributed to the industrial effluents and it is also associated with organic particles [14].

Nickel is an essential trace element for plants as well as for animals. It is principally used in its metallic form combined with other metals and nonmetals as alloys [15] Metals such as chromium, copper, and nickel have interacted with organic matter in aqueous phase and settled to the bottom, resulting in a high concentration of these metals in the sediment [16].

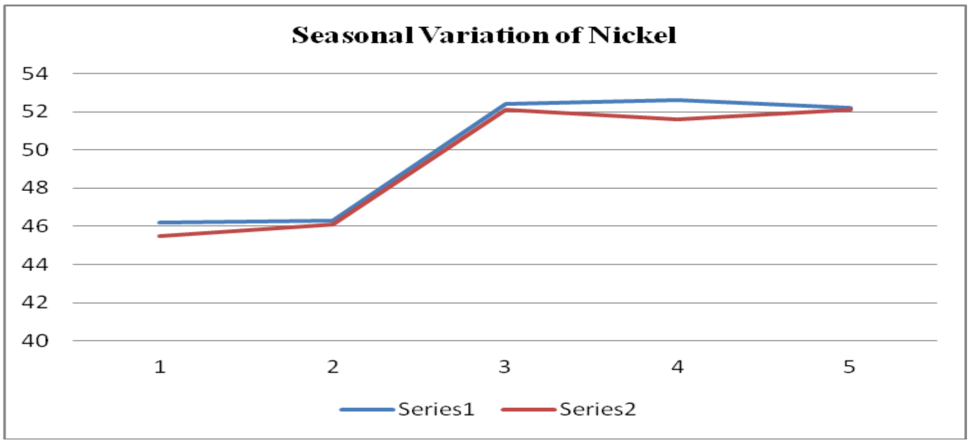

Fig.5

In PRM, Nickel has its highest concentration in site 4 and lowest in site 1 whereas in POM, the highest concentration is in site 3 and site 5 and lowest in site 1.The higher amount of nickel concentration may be due to lithogenic sources, industrial wastages and sometimes-anthropogenic activities.

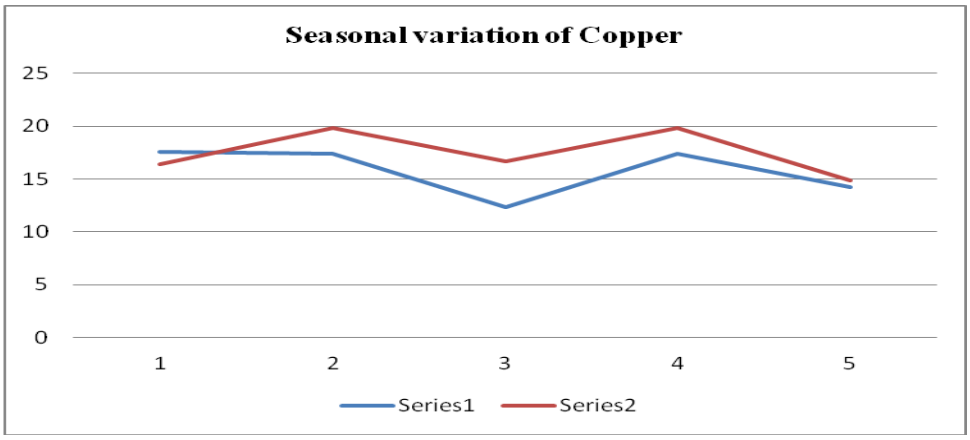

Fig.6

Copper is an essential bio molecule but the excessive presence is not essential. The Major anthropogenic sources of Cu include agrochemicals (fertilizers and pesticides), wood preservatives, electroplating and antifouling paints [17] during the monsoon period, when freshwater discharge is maximum, the copper level was high and dissolved labile copper

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concentrations were also high both at the surface and in bottom waters [18]. Low concentration was obtained in site 3 for PRM and site 5 for POM. The seasonal variation of Copper is represented in fig.6. It was reported by [19] that the sediment mobilization, biodegradation and recycling of heavy metals in sediments may contribute to decrease the concentration of heavy metals. According to [20] lower levels of copper could be the result of Cu adsorption by particulate matter and their accumulation in sediments. Extensive use of antifouling paints are source of Cu content during post monsoon was reported [21]. Eventually, it would be settled from the water column by flocculation and sedimentation [22], [20].

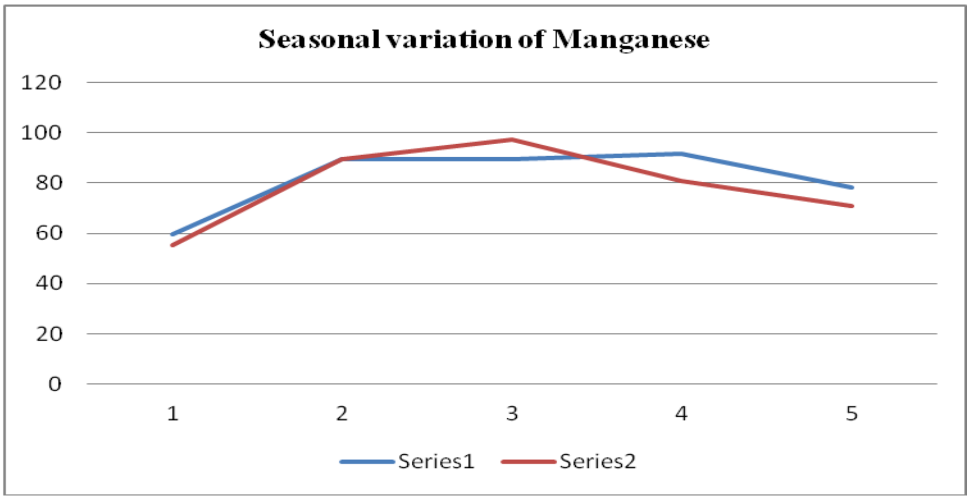

Fig.7

The variation of Manganese present in the five sites with PRM and POM is shown in fig.7 .Manganese is present in the maximum concentration in the site 4 during PRM and minimum concentration in site 1 whereas the maximum concentration in site 3 and minimum in site 1 during POM Fertilizer runoff is one of the predominant manmade sources of Mn enrichment in the aquatic environment [23].

The concentration of Iron is very high compared to all other metals present in the lake. Hence, Iron can be considered as a part of major metals rather than trace metal (Heavy metal).The concentration of Iron is less in site 2 and more in site 4 during PRM. Site 4 has the minimum and site 5 has the maximum concentration in POM. Fig 8 shows the seasonal variation of Iron with respect to PRM and POM. Iron shows positive correlation with almost all the metals present in the lake sediments. The probable enlightenment for the accumulation of heavy metal at this study area that located near the discharging point sources of heavy industrial flow, domestic wastes, municipal wastes, agricultural wastes and anthropogenic activities.[24] reported that the due to flow of organic waste that changes the pH of water leads to modify the biochemical process and increase the level of pollution in watershed while [25] reporting that the contribution of organic waste via drainage and river runoff plays a major role in rise the concentration of heavy metals in sediments.

Iron has a very close relationship with Chromium, Nickel, Manganese, Copper and Zinc. This close relationship among the metals may help in the sources of the contaminants and the approximate existence of the metals in a particular point source.

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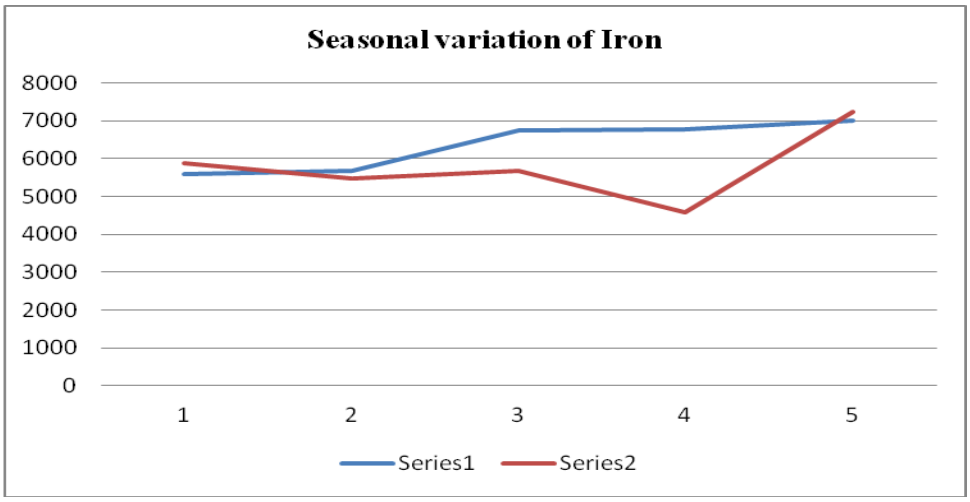

Fig.8

Zinc can enter the aquatic environment from a number of sources, including industrial discharges, sewage, effluent and runoff [26] .Zinc is present not only in rock and soil, but also in air, water and the biosphere. Plants, animals and human beings contain zinc, and this metal is used for anti corrosion coatings, roof cladding, batteries and some specialized alloys. The concentration of Zinc is min at site 5 and maximum at site 2 in PRM and minimum at site 5 and maximum at site 4 in POM. Fig 9 shows the seasonal variation of Zinc in PRM and POM.

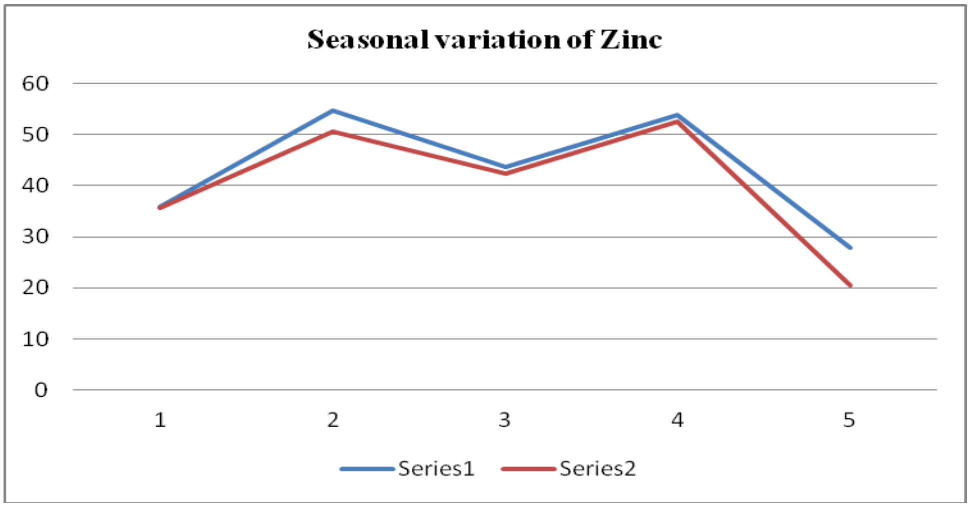

Fig.9

The variation of Titanium with PRM and POM is represented in fig 10.It is seen that the concentration of Titanium is high in PRM as compared to POM.The maximum concentration in PRM is in site 3 and the minimum concentration is in site 5.Similar pattern of distribution is seen in POM too. Titanium is considered to be non-toxic, because of its poor absorption and retention in living organisms [27]. Potential anthropogenic sources of Ti in the environment include paint pigments (TiO2 pigment accounts for the largest use of the element) and its alloys with Al, Mo, Mn and Fe, which are used extensively in aircraft, ship and missile manufacture. Metals such as chromium, copper, and nickel have

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interacted with organic matter in aqueous phase and settled to the bottom, resulting in a high concentration of these metals in the sediment [28]

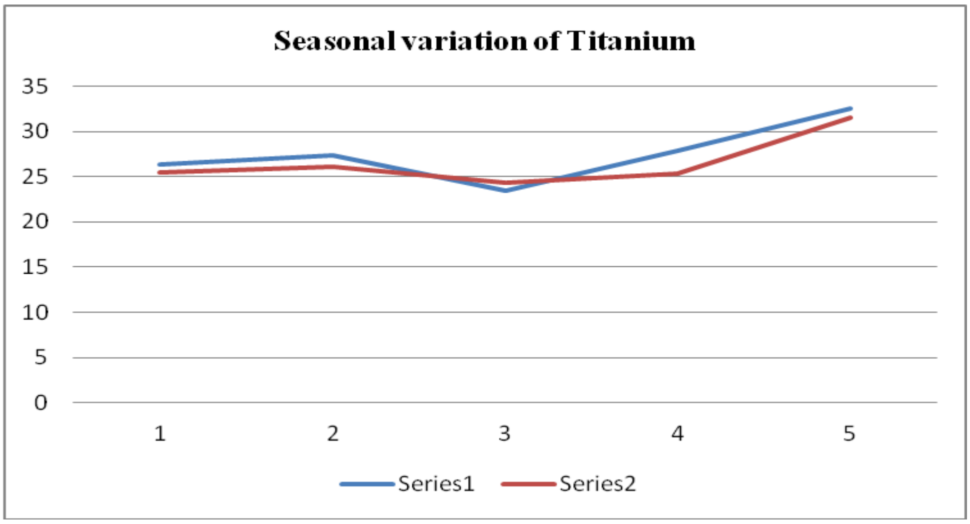

Fig.10

From the above study it is evident that Poondi lake is on the verge of Pollution. Heavy metal pollution is a serious Worldwide problem for wildlife conservation due to the metals toxic effect on the biota [29].

VI. CONCLUSION

Poondi Lake is a part of Kortalaiyar River which starts from Kaveripakkam in Vellore district, flows through Poondi reservoir and finally forms an estuary at Ennore creek. It carries contaminants along its way, depositing some in Poondi reservoir. This may a main reason for the increased level of contamination in the Lake. Heavy metal pollution may result in a serious threat to the Kortalaiyar River and hence steps should be taken to monitor the level of pollution in the lake and measures should be taken to minimize the contamination of the lake.

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