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RESEARCH ARTICLE

DYNAMIC CHANGES OF PH, ELECTRICAL CONDUCTIVITY AND SELECTED METALS IN WATER AND SEDIMENTS OF PUTHEN DAM (KANYAKUMARI DISTRICT, TAMIL NADU, INDIA

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ABSTRACT

Puthen Dam is a small reservoir regarded as mother of irrigation projects of kanyakumari District receives water from both Pechipparai and Perunchani reservoirs. Five stations were selected from the associated water bodies. The study was carried from April 2013 to April 2014.This present paper deals with the dynamic changes of pH, electrical conductivity metal ions in water and sediments of the reservoir. The seasonal variations in the water and sediment characteristics of the reservoir are presented and the significance is highlighted. The sediment pH found to have significant relationship with water pH in polynomial fit while other parameters are not significantly related. The best fit mathematical models are presented and discussed in the light of previous literature.

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INTRODUCTION

The ecosystem is an integrated unit of variable size comparing vegetation, fauna, microbes and the abiotic factors. Reservoirs are the dynamic ecosystems that possess a well defined soil, climate, flora, and fauna and have their own potential for adaptation, change and tolerance. Dams are the most important water sources and are also multistage components, because they could be used as sources of drinking water, energy production as well as for irrigation and fisheries purposes. Good quality of water resources depends on a large number of physicochemical parameters and source of any pollution load and to assess that monitoring of these parameters is essential (Reddi *et al.,* 1998). Seasonal variations and anthropogenic activities in and around the water bodies damage the aquatic ecosystem and ultimately the physico-chemical properties of water (Upadhyay *et al*., 2010). Sediments form a natural buffer and filter system in the material cycles of waters. Sediments in our rivers is an important habitat as well as a main nutrient source for aquatic organisms (Pravin *et al*., 2011).

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However works on the dynamic exchange of metal ions in water and sediments in tropical Indian reservoirs are not yet studied. With this view in mind the present investigation was carried out.

MATERIALS AND METHODS

Study Area

Puthen dam is situated near Perunchani reservoir in kanyakumari district of Tamilnadu (Figure 1). Five different stations are selected from the Puthen dam. The detailed description and geographical position of the sampling stations are presented in Table 1.

Collection and analysis of water samples

The present study was carried out for a period of 13 months from April 2013 to April 2014.Water samples were collected every month from each station using plastic bucket and cans. The water samples were analyzed by following the standard methodology of (APHA, 2012) and as per standard methods recommended by CPHEEO standard test through TWAD board, Nagercoil during the study period.

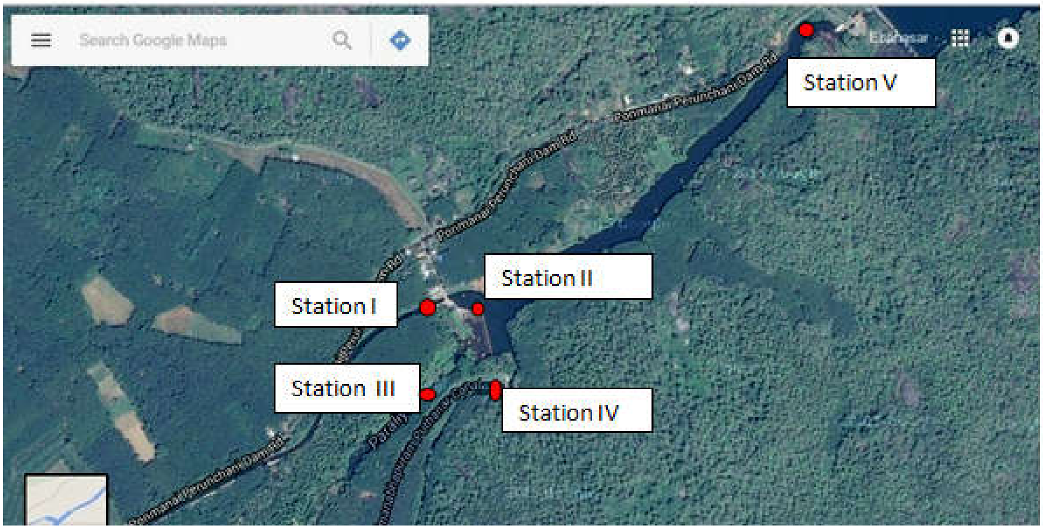

Figure 1. Map of Puthen dam showing different stations of sampling

Table 1. Geographical position and description of stations selected

S.No	Station	Discription	Latitude	Longtitude	Altitude(Above msl)
1	I	Kothayar left bank canal	8° 21'29.92"N	77 20'56.52"E	244ft
2	II	Mixing point of Kothayar and Perunchani canal water	8° 21'29.32"N	77 20'59.64"E	232ft
3	III	Outlet for Paraliyar River	8° 21'26"N	77 20'58.7"E	231ft
4	IV	Outlet for Pandiyan canal	8° 21'23.96"N	77 21'21.88"E	249ft
5	V	Water from Perunchani outlet	8° 21'47.93"N	77 21'21.64"E	252ft

Collection and analysis of sediments

Sediment samples were collected every month using Ekman dredge from the water bodies. The soil samples collected from five stations of reservoir during study period April 2013 to April 2014, were used for analysis by the standard methodology of APHA (2012) in the mobile testing laboratory, Nagercoil. Electrical conductivity, pH, potassium, iron, manganese was analyzed during the present investigation.

Stastistical analysis of data

The data on the water and soil sediments characteristics from all the five stations were analysed ANOVA using Microsoft EXCEL software to compare the difference among the physico-chemical characteristics of water and sediments of the water bodies.

Mathematical modeling

The water quality was correlated with the same parameter of sediment characteristics, using Curve expert software. The suitable mathematical model was derived and best fit models were selected based on coefficient of determination (R^2) values.

RESULTS AND DISCUSSION

The chemical and biological interactions in aquatic ecosystem are dependent on pH. According to Odum (1971) pH of an aquatic ecosystem is a function of the dissolved CO_2 content, which in turn is decreased by photosynthesis and increased by respiration.

Aquatic organisms are affected by pH because most of their metabolic activities are pH dependent (Wang *et al.*, 2002). Variations in the pH levels of water in five stations are presented in Figure 2.

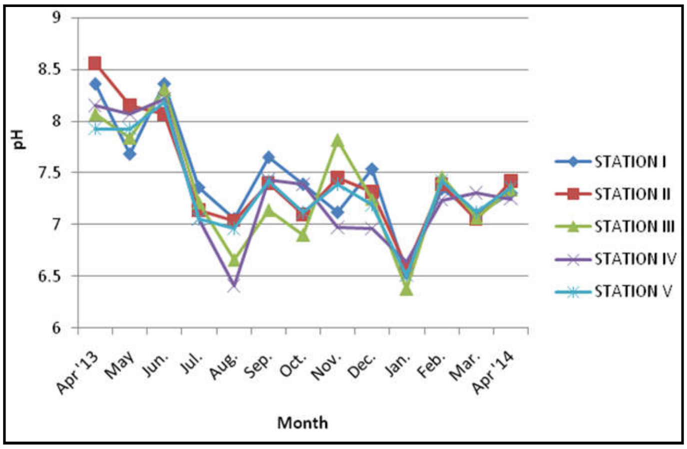

Figure 2. Seasonal variations of water pH in the different stations of Puthen Dam during the period of investigation

The variations of pH value were found to be between 6.4to 8.5. Least pH value was recorded in the month of August 2013 in station IV. The highest pH of 8.5 was recorded at station II during the month of April 2013. The pH has no significant difference ($p>0.1$) among the stations during the study period (Table.2). The highest mean value of pH 7.54$\pm$ 0.55 was recorded at station III and the least mean value of 7.31 $\pm$ 0.35 was recorded station V. Seasonal variations of sediment pH of the five different stations during the period of investigation is presented in Figure 3.

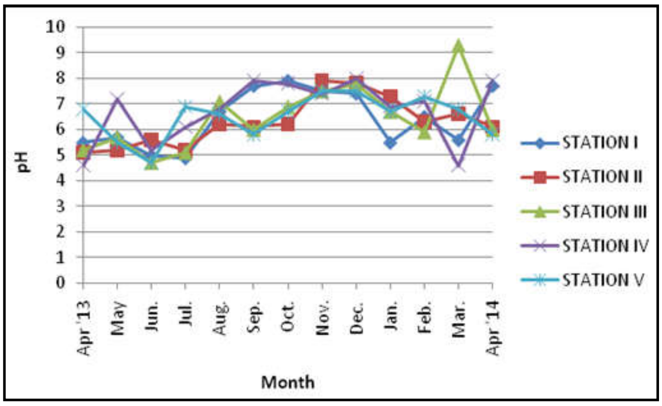

Fig. 3. Seasonal variations of sediment pH in the different stations of Puthen Dam during the period of investigation

$$y=-105.3+73.007x-17.16x^2+1.x^3-0.064565x^4$$

where,
y = water pH
x = Sediment pH

Electrical conductivity is the ability to conduct electrical conductivity and it depends upon the dissolved solids found in water and soluble matter found in sediments. It depends on the concentration of ions and nutrient status. Srinivasan (1996) reported that electrical conductivity of Pechipparai reservoir ranges from 25 to 60 µmho/cm while the results of the present study reveals that the electrical conductivity of the five stations ranged from 31 to 197 micS/cm (Figure 5). The lowest electrical conductivity 31 was recorded at station V July 2013 and the highest electrical conductivity of 197 micS/cm was recorded in June 2013.

Table 2. Analysis of variance comparing the water pH in different stations

Groups	*Count*	*Sum*	*Average*	*Variance*		
Station I	13	96.97	7.459231	0.278674		
Station II	13	96.68	7.436923	0.28454		
Station III	13	95.46	7.343077	0.307206		
Station IV	13	95.1	7.315385	0.30831		
Station v	13	95.6	7.353846	0.205242		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.204437	4	0.051109	0.184647	0.945512	2.525215
Within Groups	16.60768	60	0.276795			
Total	16.81211	64				

Table 3. Analysis of variance comparing the water electrical conductivity in different stations

ok*Groups*	*Count*	*Sum*	*Average*	*Variance*		
Station I	13	880	67.69231	1937.731		
Station II	13	815	62.69231	1873.064		
Station III	13	842	64.76923	1097.859		
Station IV	13	763	58.69231	620.3974		
Station v	13	763	58.69231	620.3974		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	794.8615	4	198.7154	0.161572	0.956943	2.525215
Within Groups	73793.38	60	1229.89			
Total	74588.25	64				

Table 4. Analysis of variance comparing the water potassium in different stations

Groups	*Count*	*Sum*	*Average*	*Variance*		
Station I	13	8	0.615385	0.25641		
Station II	13	10	0.769231	0.358974		
Station III	13	6	0.461538	0.269231		
Station IV	13	8	0.615385	0.25641		
Station v	13	9	0.692308	0.397436		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.676923	4	0.169231	0.55	0.699719	2.525215
Within Groups	18.46154	60	0.307692			
Total	19.13846	64				

The maximum sediment pH of 9.3 was observed in the month of April 2013. The minimum sediment pH 4.7 was observed in the month of March 2014 in station II. Analysis of variance comparing the sediment pH reveals no significant difference ($p>0.1$) in the five stations during the period of investigation (Table 7). The comparison of mean value reveals that the station IV had higher pH of 6.73$\pm$ 1.22 than other stations. The sediment pH have significant relationship (Figure 4) with water pH ($r=0.612$) and the best fit model is 4th degree polynomial fit.

The electrical conductivity has no significant difference ($p>0.1$) among the stations during the study period (Table 3). The high mean value of 66.67 $\pm$45.81was recorded at station I and low mean value of 58.69 $\pm$ 24.09 was recorded at station IV and V. The result of the present study is very closer to the values of Srinivasan (1996) who reported the same from Pechipparai reservoir. The slightly higher electrical conductivity was recorded than that of Srinivasan (1996) may be due to the dissolving of solute caused by the canal from Pacchipparai along its flow.

Table 5. Analysis of variance comparing the water iron in different stations

Groups	*Count*	*Sum*	*Average*	*Variance*		
Station I	12	13.52	1.126667	0.926588		
Station II	12	14.47	1.205833	0.454845		
Station III	12	11.64	0.97	0.340818		
Station IV	12	10.72	0.893333	0.199333		
Station v	12	21.42	1.785	7.967264		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.934093	4	1.483523	0.750099	0.562215	2.539689
Within Groups	108.7773	55	1.97777			
Total	114.7114	59				

Table 6. Analysis of variance comparing the water iron in different stations

SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Station I	13	2.68	0.206154	0.009526		
Station II	13	2.84	0.218462	0.010531		
Station III	13	2.68	0.206154	0.009526		
Station IV	13	2.52	0.193846	0.008192		
Station v	13	3.19	0.245385	0.057927		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.019945	4	0.004986	0.260506	0.902101	1E+09
Within Groups	1.148415	60	0.01914			
Total	1.16836	64				

Table 7. Analysis of variance comparing the soil pH `in different stations

Groups	***Count***	***Sum***	***Average***	***Variance***		
STATION I	13	83.6	6.430769	1.240641		
STATION II	13	81.6	6.276923	0.861923		
STATION III	13	83.9	6.453846	1.621026		
STATION IV	13	87.5	6.730769	1.512308		
STATION V	13	84.6	6.507692	0.690769		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.404	4	0.351	0.296119	0.879366	1E+09
Within Groups	71.12	60	1.185333			
Total	72.524	64				

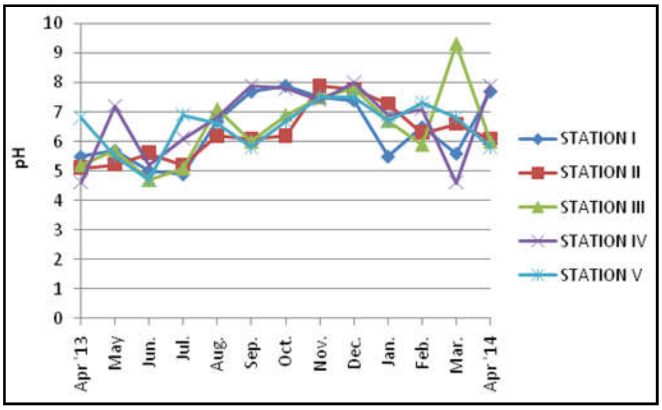

Fig. 4. Polynominal fit relating the pH levels of water and sediments

Electrical conductivity is a measure of the nature of sediments and soluble salt present in soil. The comparison of soluble salt vary from place to place. Murugasan and Manoharan (2000) in their study in Upper and Palar-poranthalar reservoirs found that the electrical conductivity varied from 30.0 to 31.6 dsm^{-2} and in between 22.1 and 27.7 dsm^{-2} respectively. Result of the present study reveals that the comparison of seasonal variation of sediment electrical conductivity of five different stations during the period of investigation is presented in figure 6. The maximum in electrical conductivity of sediments 1.34 dsm^{-2} was observed in the month of September 2013 and April 2014 in station IV. The minimum electrical conductivity value 0.05dsm^{-2} were observed in the month of July 2013 at station III. The electrical conductivity has no significant difference ($p>0.1$) among the stations during the study period of investigation (Table 8).

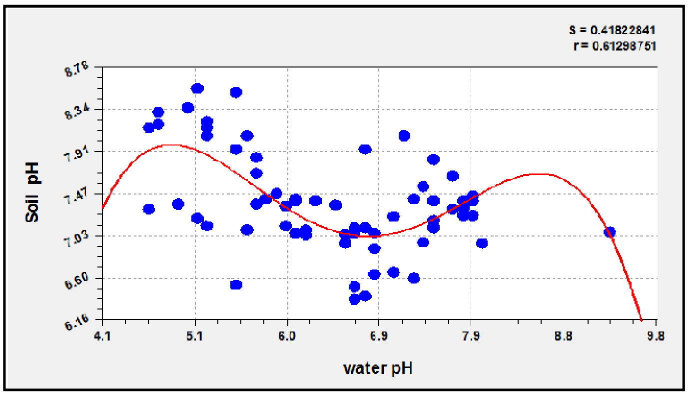

Fig. 5. Seasonal variations of water electrical conductivity in the different stations of Puthen Dam during the period of investigation

Table 8. Analysis of variance comparing the soil elecrical conductivity in different stations

Groups	*Count*	*Sum*	*Average*	*Variance*		
STATION I	13	4.4	0.338462	0.066364		
STATION II	13	4.08	0.313846	0.064526		
STATION III	13	2.69	0.206923	0.01034		
STATION IV	13	5.42	0.416923	0.186606		
STATION V	13	3.4	0.261538	0.019497		
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.327606	4	0.081902	1.179005	0.329195	1E+09
Within Groups	4.168	60	0.069467			
Total	4.495606	64				

Table 9. Analysis of variance comparing the soil potassium`in different stations

Groups	*Count*	*Sum*	*Average*	*Variance*		
STATION I	13	1662	127.8462	14937.31		
STATION II	13	1653	127.1538	11514.31		
STATION III	13	2397	184.3846	21792.92		
STATION IV	13	2187	168.2308	25486.19		
STATION V	13	2259	173.7692	23263.86		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	37639.94	4	9409.985	0.485078	0.746595	1E+09
Within Groups	1163935	60	19398.92			
Total	1201575	64				

Table 10. Analysis of variance comparing the soil iron in different stations

SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
STATION I	13	194.31	14.94692	234.6866		
STATION II	13	274.09	21.08385	743.8504		
STATION III	13	334.71	25.74692	1138.071		
STATION IV	13	151.07	11.62077	98.44426		
STATION V	13	106.16	8.166154	55.37491		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2626.184	4	656.5461	1.445865	0.230059	1E+09
Within Groups	27245.13	60	454.0854			
Total	29871.31	64				

Table 11. Analysis of variance comparing the soil manganese in different stations

SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
STATION I	13	295.83	22.75615	877.6716		
STATION II	13	431.09	33.16077	1817.033		
STATION III	13	403.32	31.02462	2239.083		
STATION IV	13	416.57	32.04385	1476.812		
STATION V	13	293.34	22.56462	681.6374		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1413.04	4	353.2599	0.249047	0.909141	1E+09
Within Groups	85106.85	60	1418.447			
Total	86519.89	64				

The comparison reveals that the station IV had the higher electrical conductivity value than the other stations studied. The high value of 0.41 ± 0.43 was recorded at station IV. The low value of 0.26 ± 0.13 was recorded at station V. The water electrical conductivity have no significant relationship with soil electrical conductivity (r=0.488) in saturation Growth model. The relationship can be expressed as

$$y= 51.056x/(-0.030+x).$$

where,
y = water electrical conductivity
x = Sediment electrical conductivity

Soruba (2002) reported that the relationship between water and sediments is not related and random. The results of present study is also agree with observation of Soruba (2002). Weathering of rocks is a major source of potassium in freshwater. The pollution may also be another reason for increasing levels of Potassium in water. Variations in the Potassium levels of five stations are presented in Figure 7. The variations of potassium were between 0 to 2 (mg/l). Potassium was absent in most of months during present investigation (Figure 8). The highest potassium level of 2 (mg/l) was recorded at station II and V during the month of June 2013.

The potassium has no significant difference (p>0.1) among the stations during the study period (Table 4).

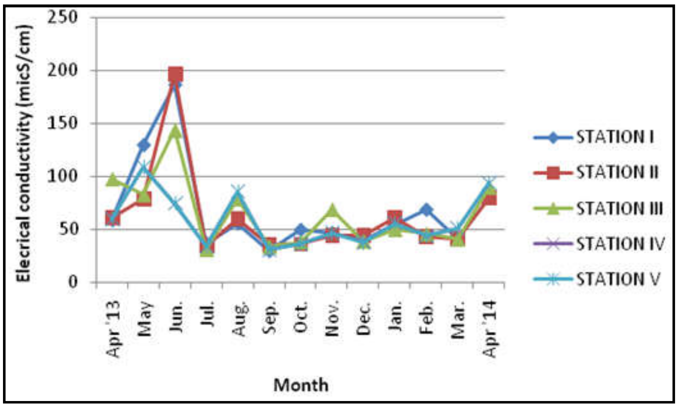

Fig. 6. Seasonal variations of sediment electrical conductivity in the different stations of Puthen Dam during the period of investigation

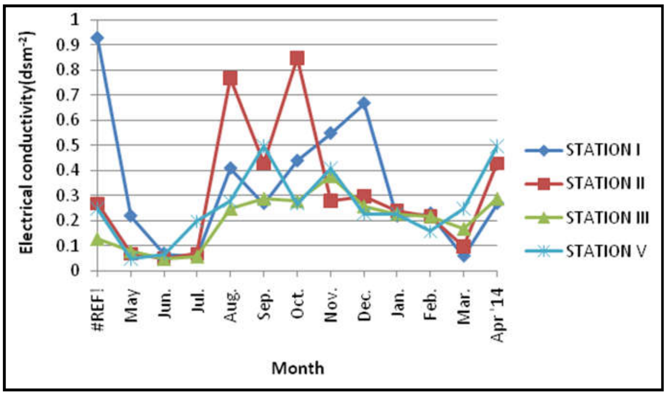

Fig. 7. Seasonal variations of water potassium in the different stations of Puthen Dam during the period of investigation

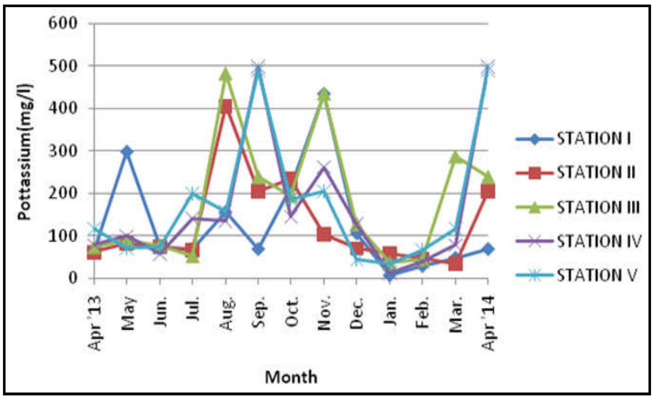

Fig. 8. Seasonal variations of sediment potassium in the different stations of Puthen Dam during the period of investigation

The high mean value of 0.69 $\pm$ 0.63 was recorded at (station V). The low mean value of 0.61 $\pm$ 0.50 was recorded station I and IV. The comparison of seasonal variation of soil potassium of the five different stations during the period of investigation is presented in Figure.8. The maximum sediment potassium level (492 mg/l) was observed in the month of September 2013 and April 2014 station IV and V. The minimum sediment potassium (34 mg/l) was recorded in the month of February, 2014 station V. Analysis of variance comparing the sediments reveals no significant difference (p>0.1) in the five stations during the period of investigation (Table 9). The comparison of mean potassium value 176.30$\pm$ 147.62 reveals that the station III had higher potassium values than the other stations studied. The sediment potassium have no significant relationship with water potassium (r=0.361) in the 5th degree polynomial fit model. The relationship can be expressed as

$$y=0.216+0.0372x-0.00045x^2+2.172x^3-4.574x^4+3.506x^5$$

where,

y = Potassium in water
x = Sediment potassium

Variations in the water iron levels of five stations are presented in (Figure 9). The variations of iron were between 0.12 to 10.59 ppm. The least iron value was recorded at station V during the month of June 2013. The iron has no significant difference (p>0.1) among the stations during the study period (Table 5). The high mean value of 1.07+ 0.93 was recorded at station I. The low mean value of 0.94 $\pm$ 0.54 was recorded station III. Iron is an essential element for vertebrates. Even though it is most abundant element in the Earth's crust, its concentration in water is quite low because of low solubility (Shaked *et al.,* 2004).

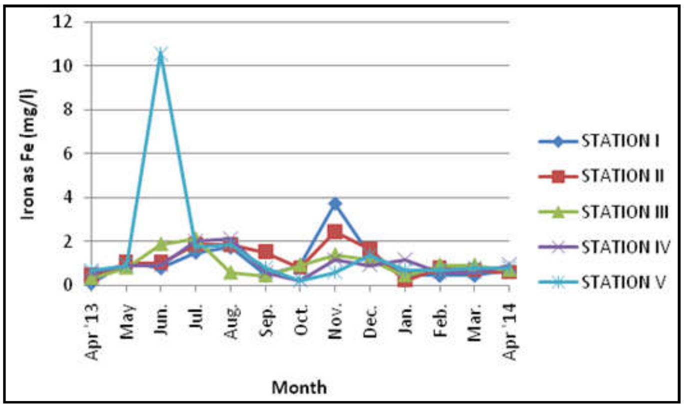

Fig. 9. Seasonal variations of water iron in the different stations of Puthen Dam during the period of investigation

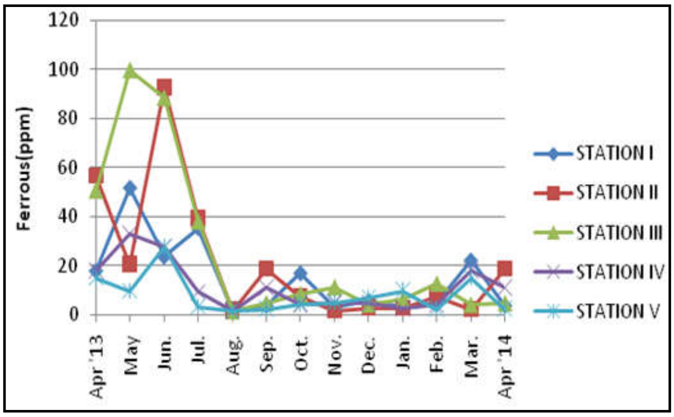

Fig. 10. Seasonal variations of sediment iron in the different stations of Puthen Dam during the period of investigation

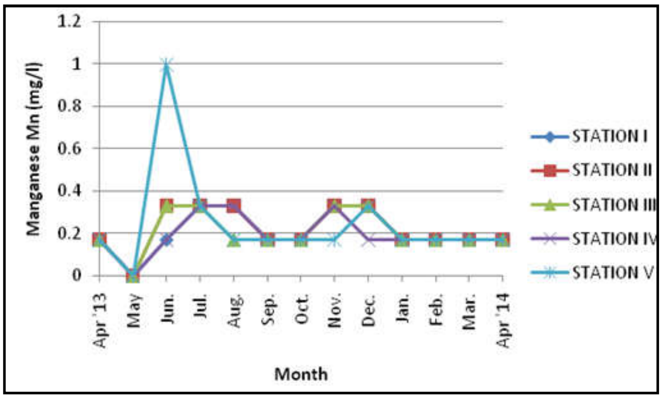

Fig. 11. Seasonal variations of water manganese in the different stations of Puthen Dam during the period of investigation

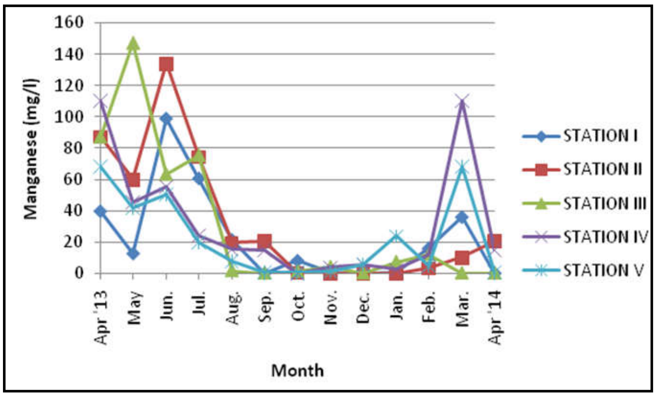

Fig. 12. Seasonal variations of sediment manganese in the different stations of Puthen Dam during the period of investigation

Iron naturally comes from the products of weathered rocks and soil around watersheds, controlled by many factors, such as geological process, soil composition, environmental temperature, precipitation and hydrology (Harris, 1992). Apart from this an important source of iron in aquatic ecosystem is anthropogenic influences (Xing *et al.,* 2006). The comparison of seasonal variation of soil iron of the five different stations during the period of investigation is presented in Figure.10.The maximum sediment iron level (99.74 ppm) was observed in the month of May 2013 station III. The minimum sediment iron of (1.42 ppm) August 2013 station III was recorded. Analysis of variance comparing the sediments reveals no significant difference ($p>0.1$) in the five stations during the period of investigation (Table 10).The comparison of mean iron value 25.74 $\pm$ 33.73 reveals that the station III had higher iron values than the other stations studied. The sediment iron is established to have no significant relationship with water iron ($r=0.350$) in the 5th degree polynomial fit model is 4th degree polynomial fit. The relationship can be expressed as

$$y=0.207-0.0065x+0.00106x^2+1.847x^3+2.385X^4-9.993X^5$$

where,

y = Iron in water

x = Sediment iron

Manganese occurs naturally in many surface water and groundwater sources and in soils that may erode into these waters. Human activities are also responsible for much of the manganese contamination in water. The reducing conditions found in groundwater and some lakes favour high manganese levels ; concentrations up to 1300 µg/l in neutral groundwater and 9600 µg/l in acidic groundwater have been reported (ATSDR, 2000). In the present investigation the manganese level remained 0 (mg/l) for stations II. Variations in the water manganese levels of five stations are presented in (Figure 11).The variations of manganese were between 0 to 1(mg/l). The least manganese value of 0 mg/l was recorded at station I to IV during the month of May 2013. The highest manganese level in station V was recorded in the month of June 2013. The manganese has no significant difference ($p>0.1$) among the stations during the study period (Table.6). The high mean value of 0.24 $\pm$ 0.24 was recorded at station V. The low mean value of 0.09 + 0.19 was recorded station IV.

The comparison of seasonal variation of soil of the five different stations during the period of investigation is presented in Figure 12. The minimum sediment manganese level 0 was observed in the month of October station IV, November station II, December I and II, 2013 . The maximum sediment manganese of 147.48 mg/l was found in the month of May 2013 in station III. Analysis of variance comparing the sediments manganese reveals no significant difference ($p>0.1$) in the five stations during the period of investigation (Table 9).The comparison of mean manganese values 33.16 $\pm$ 42.62 reveals that the station II had higher manganese values than the other stations studied. The sediment manganese is established to have no significant relationship with water manganese ($r=0.284$) in the 8th degree polynominal fit model Figure. The relationship can be expressed as

$$y=1.980+-0.373x^2+0.0324\,x^2-0.00094x^3+1.081x^4$$

where,

y = Manganese in water

x = Sediment manganese

The results of the present study reveals that the soil pH really influences the pH of the water while other factors are much relate sediment and water. This may be due to the other alkalimetals which are readily souble may play a role in causing dynamic change in pH of water and soil. The sparingly soluble nature of iron, manganese and potassium may be the reason for the non significant relationship of the same in water and sediments.

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