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Surface Water Quality Analysis in the Command Area of Perumal Tank Cuddalore District, South India

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Abstract: *The Perumal tank is the major source of irrigation water for crop production in the tail end of Cuddalore district, Tamilnadu. The tank irrigate 6503 ha of land through its 11 supply canals, which is receiving NLC mine drain water through the stream Paravanar. This water is found to carry with it a lot of suspended particles like as coal dust and small amount of fly ash etc.,. The water quality degradation sequential use and re-use of a single water supply for irrigation are well documented. Thus, in order to ensure the water quality for crop production is vital. Hence, the water quality analysis was carried out by testing the chemical parameters of sample in the Perumal tank command area. The results were analysed and compared with the BIS standards for various purposes.*

Keywords: *Water quality, mine drain, crop production, chemical properties and BIS standards.*

I. INTRODUCTION

The water is a primary natural resource for all living things; therefore, it requires at least an acceptable level of water quality (Emamgholizadeh, et al., 2014). The need of study of surface water quality is one of the major issues today due to rapid growth of population, urbanization, industrialisation and their pollution load [Ranjeeta, et al., 2011]. This may affect the water either directly or indirectly and making it unfit for various usages. Therefore now a day's fresh water has become a scarce commodity due to various factors. The re-use of waste water for irrigation was practiced over a thousands of year in many countries (Metcalf, et al., 2007). In India has been practicing waste water reuse for irrigation for the past 100 years.(Mara, et al.,2003) Many irrigation projects have to rely on lower quality and less desirable sources of water supply. In order to avoid problems when using such poor quality water supplies there must be sound planning to ensure that the quality of water available is put to best use.(A.Murugappan, et al., 2011).

Neyveli Lignite Corporation Limited, Neyveli, approximately 32,000 gallons per minute from Mines-I and 48,000 gallons per minute from Mines-II are pumped out to surface receivers, one such is Perumal tank, located at a radius of nearly 10 km from Neyveli Lignite Corporation Limited. Water from mines may contain increased iron, chlorides, manganese, and sulphate in addition to other suspended matter like clay, sand and very micro-sized lignite particles in particular washed out from the open-pit slopes. The size of the suspended particles varies mostly from colloids to 2 mm diameter. The drainage volume of lignite mining operation varies depending upon the geological and hydrological conditions. The untreated water drained out from the Neyveli lignite mines is the only source of irrigation water in the nearby command areas during non-monsoon periods. Perumal tank received such water through the stream Paravanar and the same has been utilized for irrigation in the respective command areas for more than nearly three decades. (A.Murugappan, et al.,2006) In this paper, an attempt is made to examine the physical and chemical properties of the water in the command area and water quality is assessed to determine the possible effects on the command area in the long run as a result of prolonged use of mine waters for irrigation, if any.

II. MATERIALS AND METHODS

A. The Study Area

The Perumal tank is situated between pennaiyar river basin and vellar river basin (ple see fig 1). The tank is one of the biggest tanks in Cuddalore district which is lies between in 11⁰35'N latitude and 79⁰40'E longitude an attitude of +5.50m MSL. The Perumal tank drawing water from Wallajah tank through river Paravanar, which is a mine drain water from NLC and also this carries large fow during monsoon period. A Perumal tank has an original storage capacity of 14.2 Mm³ per annum, it receives water from own

catchment of 189.44 km² and combined catchment. the current storage volume is estimated as 13.5 Mm³ and its supplied water to a command of 2,632 ha through 11 canals (ple see table 1)

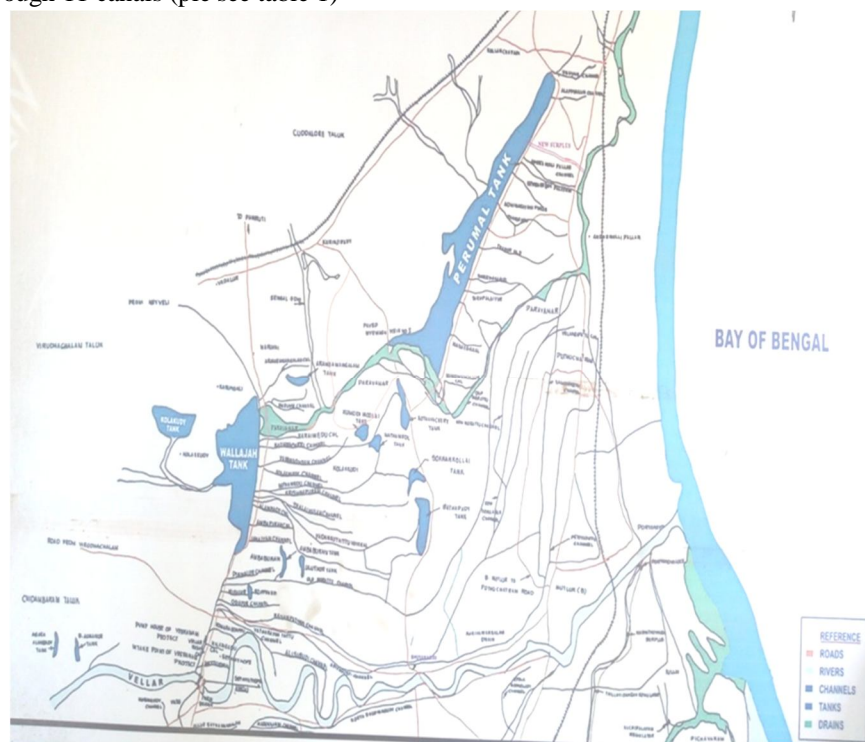


Fig. 1: Shows the study area map

Table 1: Details of the irrigation canals command area of Perumal Tank

| Sl. No. | Name of irrigation Canals | Sluice Sill level (m) | Vent size in meter (m) | Ayacut in acer | Length of the canal in Km |
|--------------|---------------------------|-----------------------|------------------------|----------------|---------------------------|
| 1 | Kundiyamallure | +10.52 | 1.60 x 1.40 | 470 | 4.83 |
| 2 | Thittuveli | +9.49 | 1.60 x 2.00 | 549 | 4.83 |
| 3 | Kallaiyankuppam | +9.10 | 1.60 x 2.00 | 460 | 5.64 |
| 4 | Sirupalayur | +7.49 | 1.60 x 2.00 | 615 | 6.15 |
| 5 | Thirthanagari | +8.76 | 1.60 x 1.40 | 550 | 4.83 |
| 6 | Old thanur | +9.16 | 1.60 x 1.60 | 600 | 6.44 |
| 7 | New thanur | +8.74 | 1.60 x 2.11 | 536 | 4.83 |
| 8 | Sambareddypalyam | +8.99 | 1.60 x 1.60 | 516 | 6.15 |
| 9 | Andalmullipallam | +12.00 | 1.60 x 2.10 | 615 | 4.83 |
| 10 | Alapakkam | +9.14 | 1.40 x 1.40 | 742 | 5.83 |
| 11 | Umaiyan mathagu | +6.39 | 1.60 x 1.60 | 850 | 6.4 |
| Total Ayacut | | | | 6503 | |

B. Sampling and Analysis

Water from the 11 supply canals at three stages i.e Head, Middle and Tail was sampled monthly from august 2017 to December 2017 at 33 monitoring sites distributed over the entire command area (ple see fig 2). The water samples were taken manually from the centre of the supply canals at a depth of 5 cm at the respective monitoring site. The collected sample are stored at 4° c temperature and transported to the laboratory.

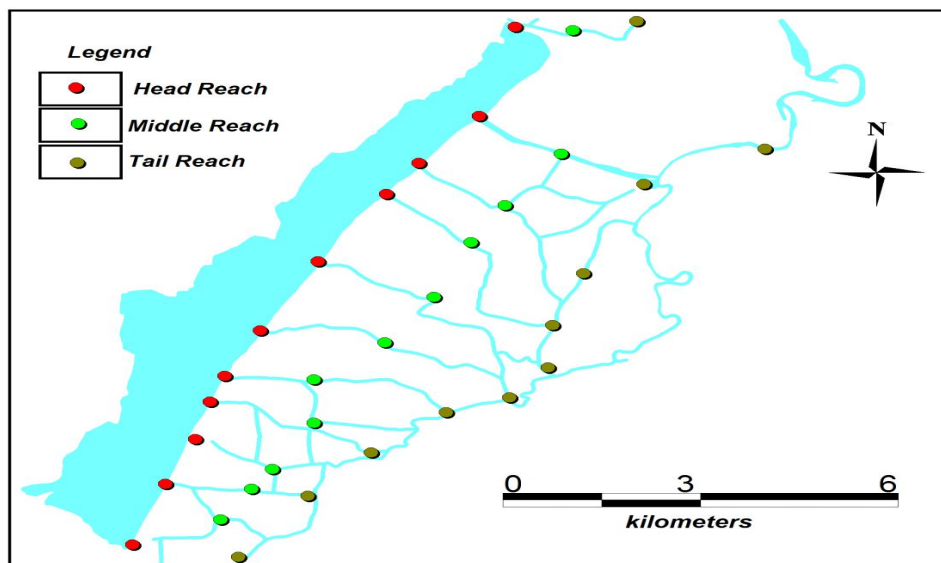


Fig. 2: Map showing the location of sampling points.

The twelve parameters such as Ph, Alkalinity, Hardness, Chloride (Cl), TDS (Total Dissolved Solids), Fluoride (F), Iron (Fe), Ammonia (NH₃), Nitrite (NO₂), Nitrate (NO₃), Phosphate (PO₄) and Residual Chloride (R.C) were analyzed using Tamilnadu Water Supply And Drainage Board Testing kit. Sodium (Na), Calcium (Ca), Magnesium (Mg), Potassium(k) were tested in Annamalai University Environmental Laboratory with standard procedure APHA (American Public Health Association).

C. BIS standards

Water may become poor in quality due to presence of some chemicals or microbial contamination. Many salts/chemicals are normally dissolved in water. Bureau of Indian Standards (BIS) have prescribed guideline values for various water quality parameters (ple see table 2). When these guidelines values are exceeds some diseases may be caused and may also affect the aquatic life and crops.

Table 2: Show the BIS Drinking water standards (2012)

| Sl No. | Water Quality Parameters | BIS 10500 : 2012 permissible limit in the absence |
|--------|------------------------------|---|
| 1 | Ph | 6.5 -8.5 |
| 2 | Alkalinity | 200 -600 mg/l |
| 3 | Hardness | 600 mg/l |
| 4 | Chloride (Cl) | 250 -600 mg/l |
| 5 | TDS (Total Dissolved Solids) | 500 -2000 mg/l |
| 6 | Fluoride (F) | 1 -1.5 mg/l |
| 7 | Iron (Fe) | 0.3 mg/l |
| 8 | Ammonia (Nh ₃) | 0.5 mg/l |
| 9 | Nitrite (NO ₂) | - |
| 10 | Nitrate (NO ₃) | 45 mg/l |
| 11 | Phosphate (PO ₄) | - |
| 12 | Residual Chloride (R.C) | 0.2 mg/l |
| 13 | Sodium (Na) | 200 mg/l |
| 14 | Calcium (Ca) | 75 -200 mg/l |
| 15 | Magnesium (Mg) | 30 – 100 mg/l |
| 16 | Potassium (k) | - |

(Source: Tamilnadu Water Supply And drainage Board)

III. RESULTS AND DISCUSSION

A. Surface Water Quality For Perumal Tank

- 1) **pH:** pH is an important factor that determines the suitability of water for various purposes, including toxicity to animals and plants. The pH is a measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. It has no direct adverse effect on health, however a low value below 4.0 will produce sour taste and higher value above 8.5 shows alkaline taste. As per WHO and BIS standard pH for aquatic life is in the range of 6.5 to 9.0 and drinking purpose standard is 6.5 to 8.5 (please see table 3). The highest concentration of pH 8.5 was at Kundiyamallure head reach and lowest value was found at Aandalmullipallam, Aalapakkam and Umaiyam Mathagu. The average value of pH in Perumal tank command area was 7.5 (please see fig.3.1). The pH level is well within the permissible limits.
- 2) **Alkalinity:** Measuring alkalinity is important in determining a stream's ability to neutralize acid pollution from rainfall or waste water. It is one of the best measures of sensitivity of the stream to acid inputs; there can be long-term changes in alkalinity of streams and rivers in response to human disturbances. The highest concentration of alkalinity 150 mg/l was found at Thittuveli head reach, T.Kalayankupam middle reach and Aalapakkam tail reach. The lowest value was found at Aandalmullipallam tail reach and NewThanure middle reach. The alkalinity levels are well within the permissible limits. The average value of alkalinity in Perumal tank command area was 90 mg/l (please see fig 3.2).
- 3) **Hardness:** Hardness is defined as the concentrations of calcium and magnesium ions, expressed in terms of calcium carbonate. This mineral in water can cause everyday problems. There are major non-metallic constituents in water. The hardness values were determined; the obtained results show the highest value of hardness 800 mg/l was found at Aalapakkam tail reach and lowest value 340 mg/l was at middle reach of Thirthanagiri and Aandalmullipallam. The average value of hardness in Perumal tank command area is 570 mg/l (please see fig.3.3). Hardness of the water is within the permissible limits for stations up to 9.
- 4) **Chloride:** Chloride occurs naturally in all types of water. This is the most common inorganic anion present in water. High concentration of chloride is considered to be an indicator of pollution due to organic wastes of animal or industrial origin. Chloride is troublesome in irrigation water and also harmful to aquatic life. Main sources of chloride in waters are sediment, sewage and trade and industrial effluents. Sewage with man and animals excrete which are rich in chloride content. The BIS suggested standard of chloride is 1000 mg/L. The highest concentration of chloride 300 mg/l was found at Kundiyamallure head reach and lowest value 90 mg/l was obtained at Thirthanagiri regions. The concentration of chloride level in the water is well within the permissible limits. The average value of chloride in Perumal tank is 180 mg/l (please see fig.3.4)
- 5) **Total Dissolved Solid (TDS):** TDS is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized, micro-granular (colloidal sol) suspended form. The principal application of TDS is in the study of water quality for streams, rivers, lakes, although TDS is not generally considered as a primary pollutant. The highest value for TDS 1452 mg/l was found at Aalapakkam tail reach and lowest value 684 mg/l was obtained at Thirthanagiri tail reach. The average value of TDS in Perumal tank command area is 1068 mg/l (please see fig.3.5). TDS levels in the water are well within safe limits.
- 6) **Fluoride:** Fluoride is an inorganic monovalent anion of fluorine with the chemical formula F⁻. Fluoride is the simplest anion of fluorine. The highest value of fluoride 2.0 mg/l was found at T.Kalayankupam head reach, middle reach, and lowest value 0.2 mg/l was obtained at Thittuveli head reach. The average value of fluoride in Perumal tank command area was 1.1 mg/l (please see fig.3.6). Head region has value beyond the permissible limits from Thittuveli to Old-Thanure locations, middle regions have value beyond safe limit at Thittuveli to Old thanure, tail regions have value on the safe line. Hence it is not safe, may cause adverse effect.
- 7) **Iron:** Iron is a chemical, it is the first metal in transition series. The highest value of iron 2.0 mg/l was found at Old Thanure tail reach, New Thanure head reach and Aalapakkam tail reach. The average value of iron in Perumal tank command area was 1.0 mg/l. The level exceeds the safe limit in head region at locations New Thanure and in medium regions at locations Old Thanure and Aalapakkam. Iron levels are well within the safe regions in most of the locations (please see fig.3.7)
- 8) **Ammonia:** Ammonia or Azane is a compound of nitrogen and hydrogen. Ammonia is colourless with a characteristic pungent smell. It is a common nitrogenous waste particularly among aquatic organisms and it contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to food and fertilizers. Ammonia levels vary differently at various regions. The ammonia values were tested; the obtained results show the highest value of ammonia 2.0 mg/l was found at head and tail reach of Thittuveli, head reach of Thirthanagiri, and the tail reaches of Aandalmullipallam and Aalapakkam. The remaining all stations had the lower value of 0.5 mg/l. The average value of ammonia in Perumal tank command area was 1.0 mg/l (please see fig.3.8).

- 9) **Nitrate:** Increasing concentration of nitrogen compounds in river and reservoir lead to eutrophication and could be due to sewage water with agriculture wastes. Nitrate concentration also depends on the activity of nitrifying bacteria which in turn get influenced by presence of dissolved oxygen. Water containing more than 45 mg/l of nitrate is not considered for drinking purpose Among the 33 samples in 11 canals, the highest value of nitrate 75 mg/l was found at Old Thanure, New Thanure, Samparettipalayam, Alapakkam and Umaiyam mathagu regions. The lowest value 20 mg/l was found at Sirupalaiyur, Thirthanagiri regions. The average value of nitrate in Perumal tank command area was 45 mg/l (ple see fig.3.9).
- 10) **Residual chlorine:** Residual chlorine is the amount of chlorine that remains in the water after certain period or contact time. There are three forms of residual chlorine in water treatment they are: Free, Combined and Total. The Residual Chlorine value were tested, the obtained results show the highest value for RC 2.0 mg/l at Old Thanure head reach and lowest value 0.0 mg/l is obtained at Thittuveli, T.Kalayankuppam, Sirupalaiyur and Thirthanagiri regions. The average value of RC in Perumal tank command area was 0.2 mg/l (Pl. see fig.3.10). Residual chlorine levels at almost all points were above the permissible limit.
- 11) **Sodium:** The above figure show the sodium concentration obtained from the sampling results in the study area. The sodium is often taken important parameter in deciding the suitability of water for irrigation. Excess sodium in water produces the undesirable effect on water infiltration rate. As per the BIS standards, if the water containing more than 200 mg/l of sodium is not fit for drinking purpose. Among the 33 samples in 11 canals, the highest value of sodium 273.35 mg/l was found at the middle reach of Sirupalaure and lowest value 170.66 mg/l was obtained at Samparettipalayam tail reach. Except the tail reaches of T. Kallayankuppam, Thirthanagiri and umaiyam mathagu and the entire reach of Samparettipalayam all are above the permissible valve. The average value of Sodium in Perumal tank command area was 225 mg/l. (pl see fig.3.11)
- 12) **Calcium:** The Calcium concentration was tested and the results show the highest value of calcium 58.74 mg/l was obtained at Thittuveli head reach and lowest value less than 1.00 mg/l was obtained at T.kalayankuppam tail reach regions. The average value of calcium in the Perumal tank command area was found 30 mg/l. The permissible value of calcium for drinking purpose is 75 to 200 mg/l (according to BIS), the obtained value of calcium at all locations were below the permissible limits (Pl. see fig.3.12).
- 13) **Magnesium :** Magnesium concentration also was tested, which is directly related to hardness. Magnesium is a co-factor for various enzymatic transformations within the cell especially in the trans-phosphorylation in algal, fungal and bacterial cell. According to the BIS standards the permissible range of magnesium is 30 to 100 mg/l for drinking purpose. The maximum value of magnesium (32.89 mg/l) was found at Thittuveli head reach, the remaining places all are below 30 mg/l were obtained. The minimum value of 1.10 mg/l was obtained at T. Kalayankuppam, Samparettipalayam and Umaiyam mathagu regions. The average value of magnesium in Perumal tank command area was 15.8 mg/l (Pl. see fig.3.13).

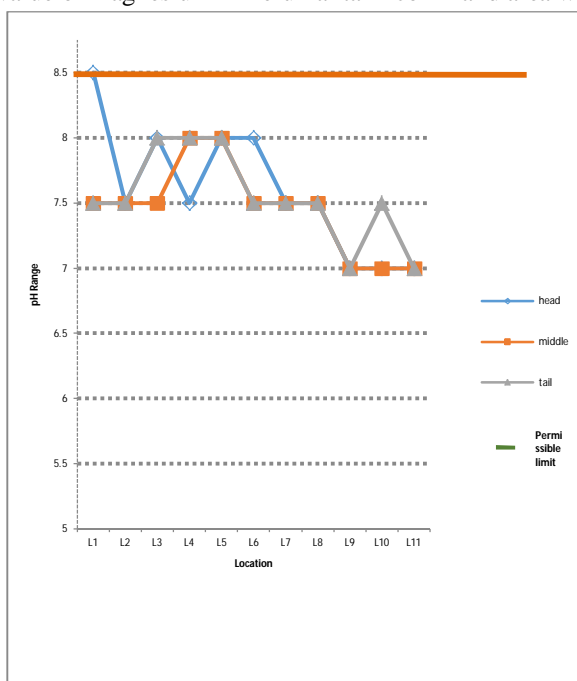


Fig.3.1 pH Range

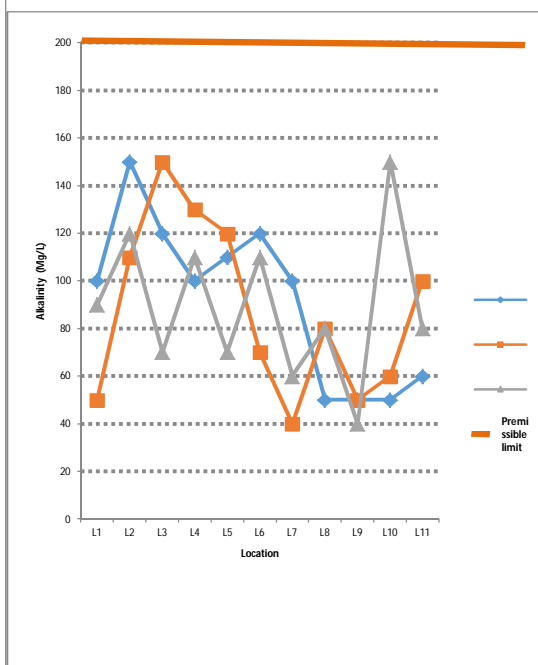


Fig. 3.2 Alkalinity Range

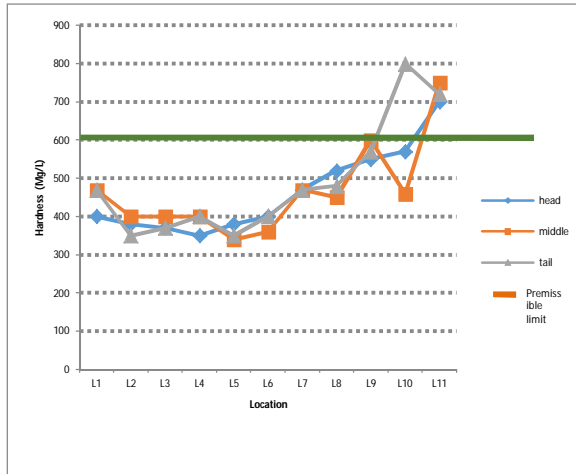


Fig. 3.3 Hardness Range

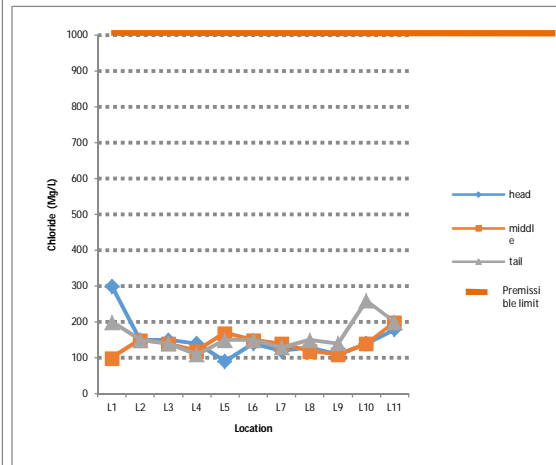


Fig. 3.4 Chloride Range

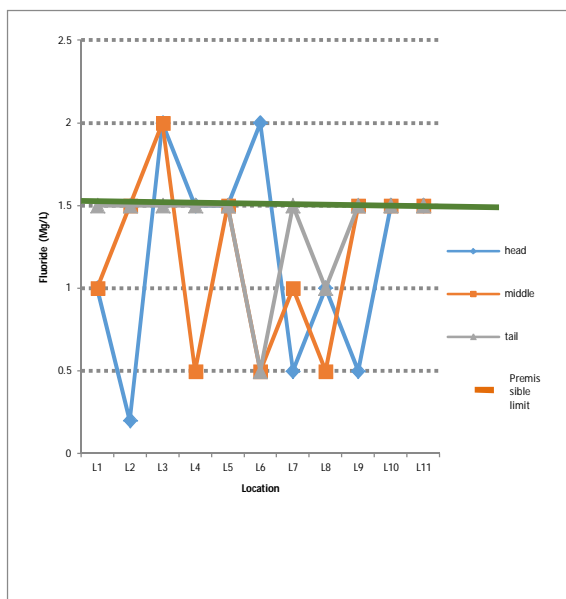


Fig. 3.5 Fluoride Range

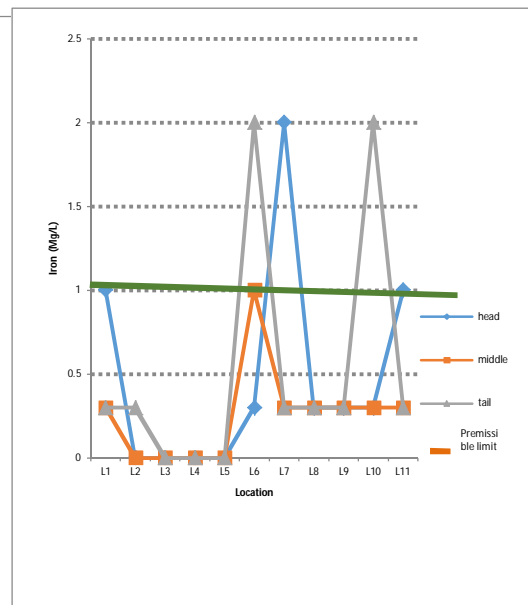


Fig. 3.6 Iron Range

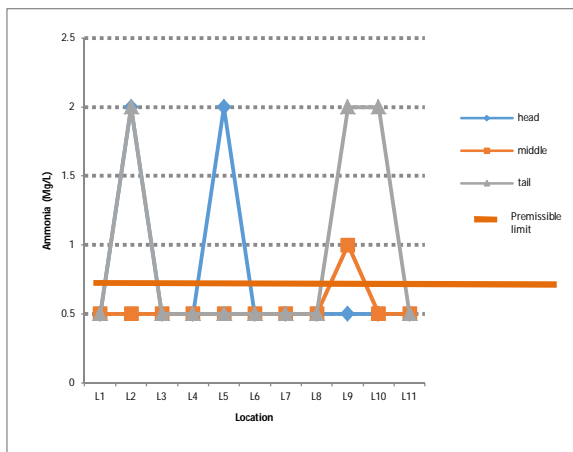


Fig. 3.7 Ammonia Range

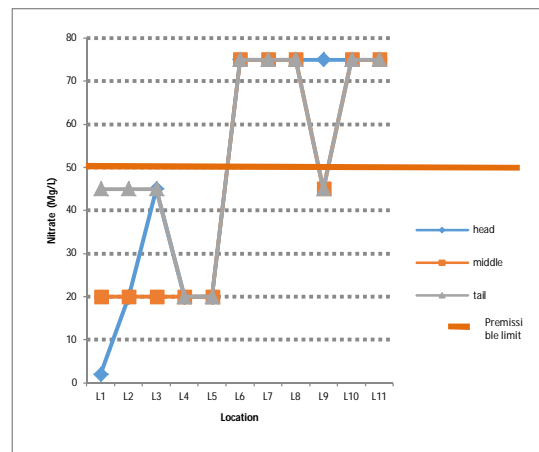


Fig. 3.8 Nitrate Range

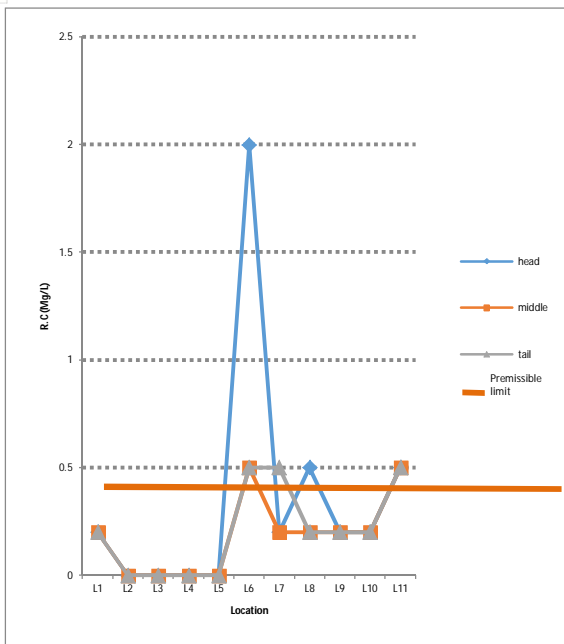


Fig.3. 9 R.C Range

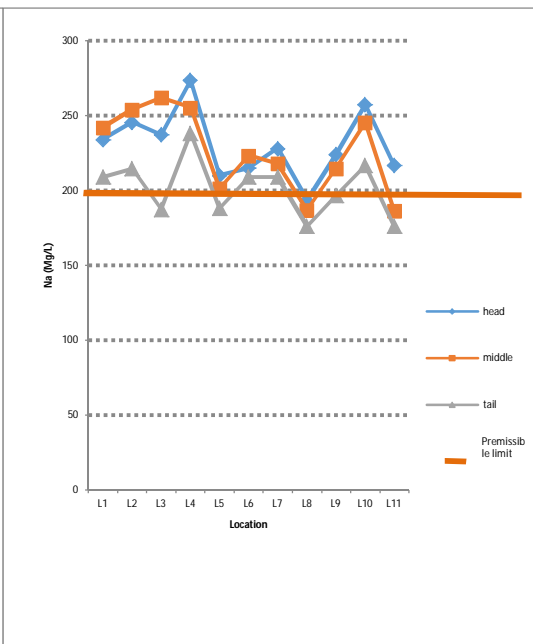


Fig. 3.10 Sodium Range

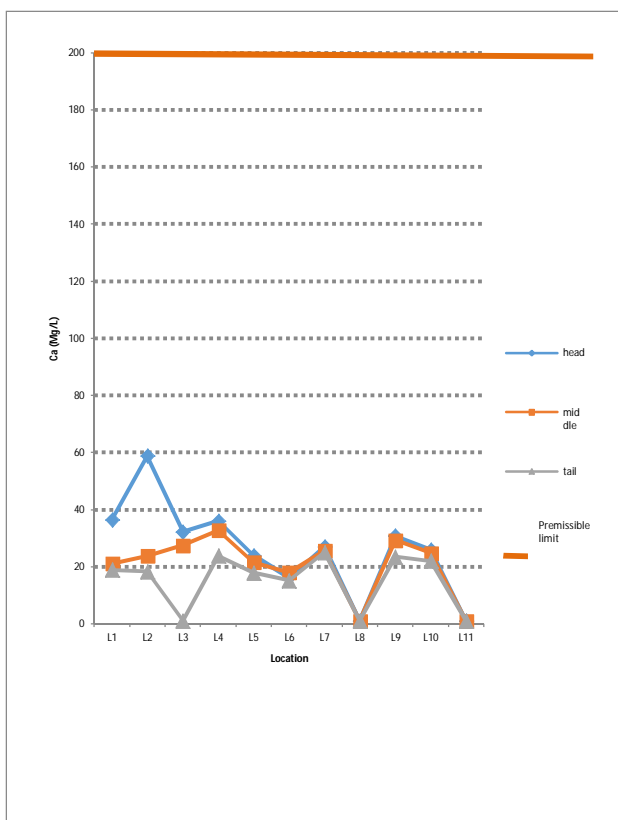


Fig. 3.11 Calcium Range

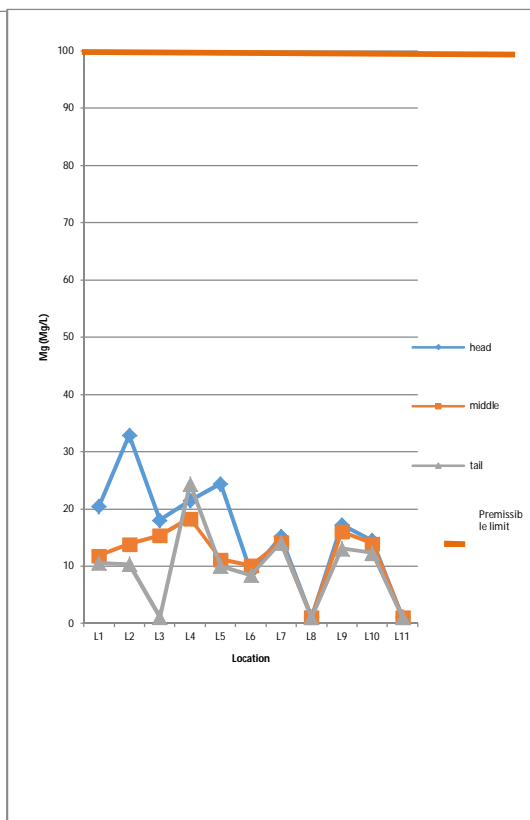


Fig. 3.12 Magnesium Range

L1-Kundiyamallure L 2-Thittuveli L 3-Kallaiyankuppam L 4- Sirupalayur L 5- Thirthanagari
 L 6- Old thanur L 7- New thanur L 8- Sambareddypalyam L 9- Andalmullipallam
 L 10- Alapakkam L 11- Umaiyan mathagu

Fig 3: Shows the geographic representative of chemical parameters

Table 3: Shows the average values of the chemical parameters at different reach

| Sl. No. | parameters | Head reach mean values | Middle reach mean values | Tail reach mean values | BIS 10500 : 2012 permissible limit in the absence |
|---------|------------|------------------------|--------------------------|------------------------|---|
| 1 | pH | 7.4 | 7.4 | 7.45 | 6.5 -8.5 |
| 2 | Alkalinity | 91.8 mg/l | 87.27 mg/l | 9.8 mg/l | 200 -600 mg/l |
| 3 | Hardness | 462.72 mg/l | 463.63 mg/l | 489.09 mg/l | 600 mg/l |
| 4 | Chloride | 150 mg/l | 140 mg/l | 161.81 mg/l | 250 -600 mg/l |
| 5 | TDS | 845.45 mg/l | 829.09 mg/l | 888 mg/l | 500 -2000 mg/l |
| 6 | Fluoride | 1.2 mg/l | 1.18 mg/l | 1.36 mg/l | 1 -1.5 mg/l |
| 7 | Iron | 0.5 mg/l | 0.3 mg/l | 0.5 mg/l | 0.3 mg/l |
| 8 | Ammonia | 0.71 mg/l | 0.6 mg/l | 0.9 mg/l | 0.5 mg/l |
| 9 | Nitrite | 0.4 mg/l | 0.4 mg/l | 0.3 mg/l | - |
| 10 | Nitrate | 50.63 mg/l | 47.27 mg/l | 54.09 mg/l | 45 mg/l |
| 11 | Phosphate | 1.3 mg/l | 1 mg/l | 0.9 mg/l | - |
| 12 | RC | 0.4 mg/l | 0.2 mg/l | 0.3 mg/l | 0.2 mg/l |
| 13 | Sodium | 230.96 mg/l | 228.56 mg/l | 234.20 mg/l | 200 mg/l |
| 14 | Calcium | 26.34 mg/l | 25.60 mg/l | 26.23 mg/l | 75 -200 mg/l |
| 15 | Magnesium | 18.04 mg/l | 17.80 mg/l | 18.30 mg/l | 30 – 100 mg/l |
| 16 | potassium | 12.43 mg/l | 12.07 mg/l | 12.35 mg/l | - |

IV. SUMMARY AND CONCLUSIONS

A. Summary

Water samples were collected from 33 points in 11 canals in the command area of perumal tank. The water samples are tested using field testing kit (TWAD) and few parameters tested in the environmental lab at Annamalai University. The obtained results were analysed to ascertain the status of water quality in Perumal tank command area.

pH, Hardness, TDS, and Fluoride levels in all stations were well within the permissible range.

Alkalinity, Calcium and magnesium levels in all station are fare below the permissible range. Among these parameters the calcium and magnesium are an important parameters in decidng the water quality standards for agriculture. If these parameters are low the sodium level may be high, which may lead to cause water infiltration rate problems.

Some specific toxic ions such as chloride, iron and sodium were analysed. Chloride levels are well below the permissible range, but the iron and sodium level just above the permissible limit in all the head reaches.

Ammonia, Nitrate, and Residual chlorine also shows their levels above the permissible limits in the head reaches of all stations. Ammonia and nitrate is seldom present in excess of 1 mg/l unless ammonia fertiliser or waste water is being added to the water supply (Ayers, R.S. and D.W. westtcot, FAO 1976). Since, the high value of ammonia and nitrate may be due to either wastewater or farm activities in the study area.

Apart from the above, Nitrite, Phosphate and potassium were also analysed. These parameters should not be found in drinking water but in this water ranged from 0.4 mg/l to 2.0 mg/l except potassium. The maximum value of potassium was found at the head reaches of Sirupalaure sluice canal.

V. CONCLUSIONS

In this study area, the preliminary study was carried out from August 2017 to Dec 2017 to test the surface water quality to find the variations in water for various purposes, if any. Among all the samples nearly 30 % data only found the range out of BIS standards. From the analyses this paper conclude there is no great variations found with the BIS drinking water standards, but in some extent there is significant effect which may possible to cause infiltration rate problems. The colour of the water in the study area also found from light dirty white to clear.

Hence, the Perumal tank command area has no adverse effect on the water to hamper the drinking standards. Furthermore, a continuous monitoring is essential to find any salinity problems or soil permeability problem in the study regions.

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