

**ANALYSIS OF SELECTED PHYSICAL AND CHEMICAL
PARAMETERS AND EVALUATION OF WATER
QUALITY OF A RAIN-FED TANK**

By

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Reg. No. '94 PLS 05

A THESIS SUBMITTED TO
THE AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND HIGHER EDUCATION
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MASTER OF SCIENCE IN LIFE SCIENCES

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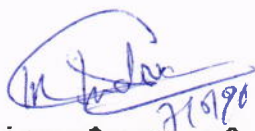
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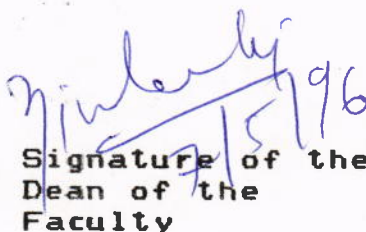
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CERTIFIED AS BONAFIDE RESEARCH WORK.



Signature of the
Head of the
Department



Signature of the
Dean of the
Faculty



Signature of
the Guide

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Introduction

INTRODUCTION

Fresh water has been always of vital importance to men. Of the total amount of fresh water, only 2.4 per cent is distributed on the main land, of which only a small portion can be utilized as fresh water. The available fresh water to man is hardly 0.3 - 0.5 per cent of the total water supply on earth and therefore its judicious use is imperative (Hegde and Kale, 1995).

Water is assuming ever greater importance in the world economy. Almost all the living organisms depend on water for their life activities. Owing to the fast growth of population and rise in its standard of living and also due to the fast development of modern industrial technology, need for fresh water is more.

Fresh water habitat occupy relatively small portion of the earth's surface. These are of the greatest interest to man, because they provide the more convenient and the cheapest source of water for domestic and industrial needs and also the most convenient waste disposal system.

Though lakes are the principal form of inland standing surface water, ponds and pools by their individual characteristics are also equally important to men, fish and water birds (Hegde and Kale, 1995).

Since the time of Forel (1877) a mass of information has been accumulated in various aspects of limnology. The lentic habitat and biota have been considerably studied by Welch (1948), Hutchinson (1957), Macan (1963) and Frey (1963). The area and volume of lentic water on earth have increased remarkably during twentieth century because of the impoundment of rivers to form both medium and large reservoirs (Avakian and Fortunatov, 1972; Ackermann et. al., 1973; Fels and Keller, 1973) and also due to the construction of countless small farm ponds and stock tanks (Dendy, 1963).

In the past, if one water source failed, it would be replaced by another one. Clean surface and underground water were in abundant supply. Now the picture is drastically changing; on one hand the water demand greatly increases due to growth of population, higher degree of urbanization, increasing industrialization, and higher standards of living, and on the other hand water quality deteriorates due to adoption of easy and economic disposal of untreated waste into the nearby water bodies.

The high rate of increase of human population, and the tremendous industrial growth and urbanization in India have created much problems of disposal of waste products which are indiscriminately discharged in nearby rivers, reservoirs, lakes and tanks and even in adjoining fields with almost no pre treatment. This ultimately causes change in the quality of water and its suitability for domestic use, recreation, agricultural use and fisheries.

Most of the fresh water systems in India are being polluted though they are used for nation's economy. People have now understood that dilution is not the solution for pollution of any kind. Unless the wastes are recycled and the polluted water is being treated before it is allowed to mix with the natural sources, there would not be any non-polluted water for the utilization of human beings, animals and plants.

Pollution survey of natural water in India was initiated as early as 1940. Hora (1942), Chacko and Sreenivasan et. al. (1954, 1955, 1966, 1972), Agarwal (1976), Sreenivasan et. al. (1977), Hackumat (1974), Rai (1975), Boralkar (1980) and Mitra (1982) studied the general limnology and the level of pollution of major rivers of India.

Investigation carried out by Rai and David (1966) shows that the river 'Ganges' is one of the most heavily polluted rivers in India. The various industries located on the banks of river Hoogly and the sewage directly disposed into the river heavily pollute the water mass (Seth and Bhaskaran, 1950). Municipal sewage and effluents from the paper pulp factories are discharged into the river Gomathi throughout its 35 km stretch in Uttar Pradesh (Bhaskaran et. al., 1963). The river Yamuna is polluted by DDT factory wastes which requires atleast 8,000 times dilution to eliminate harmful effects (George et. al., 1965). An official report reveals that the pollution of the Yamuna near Delhi is caused by the discharge of 200 million litres of effluents.

Several studies are available on the deterioration of water quality of Indian rivers. The prominent studies are by Upadhyay et. al. (1982), Raina et. al. (1984), Anwar and Siddiqui (1988) and Mishra et. al. (1990) and these have been reviewed by Trivedi (1989, 1990):

The problem of fish mortality, damage to fishes and other aquatic problems due to pollution of inland water by industrial and domestic waste have been examined earlier by several workers Ganapati et. al. (1950), Banerjee and Motwani, 1960; George et.al. (1960); and Saxena et. al. (1966).

Owing to continuous usage of water in ponds and lakes, it has become necessary to evaluate the quality of these lentic water system. Further a complete survey portraying the physical, chemical and biological conditions of inland water system is necessary for increasing the fishery resources of our country.

Hence in the present study a rain fed fresh water tank at Kurichi in Coimbatore district was selected to study its physical and chemical characteristics and to assess its water quality for domestic, agricultural and piscicultural practices.

Review of Literature

REVIEW OF LITERATURE

Though our knowledge on tropical fresh water is still limited, a deal of limnological work has been carried out in India. The fresh water of temperate countries have received much more attention. It is difficult to trace the Indian history of limnological studies due to its diversity and most of the earlier works were carried out from a limnological point of view.

LIMNOLOGICAL STUDIES ABROAD:

Birge and Juday (1922) studied the composition of plankton of Wisconsin inland lakes. The organic content of lake water was studied by Birge and Juday (1927). Oxygen stratification in lakes were discussed by Rossolime (1928). Fish and Charles (1929) surveyed the physical, chemical and biological parameters of Eree lake. The lake was in relatively normal condition without chemical, sewage pollution or silt deposits. Robinson et. al. (1930) determined the organic phosphorus in lake water.

McMurry et. al. (1933) discussed the objectives and methods in the lake Inventory in Michigan. Checking of temperature, O_2 , CO_2 , acidity and hardness at different depths and study of fish population were made. Beauchamp (1939) studied the hydrobiology of lake Tanganyika. The temperature and chemical analysis (especially oxygen, nitrate) made at several stations at frequent intervals revealed an insight into the circulation of the epilimnion and revealed the mechanism by which the upper layers of the hypolimnion were mixed during the cool season.

Hardman (1941) studied the surface tension of Wisconsin lake water. Physical, chemical and biological factors were involved in lowering the surface tension of the lake water. Hardness of the water within certain limits, did not affect surface tension, nor did variations in pH ranging from 4.5- 8.5. Ekman (1943) analysed the twenty three small lakes of Dalarna in Sweden. A well developed thermocline was observed in a depth of about 2.6 metre and the temperature decreasing to 6.9°C within 1 metre. A marked degree of thermal stability and chemical and physical factors limiting and controlling animal life of lake Tanganyika were briefly discussed by Neauchamp (1946). A limnological study of Erh Hai, Yunnan in China was made by Hsiao (1946). It had no stratification as the sub surface temperature being fairly uniform. Its oxygen content varied between 3.5 and 5.4 ml/l.

Hamano (1946) studied the diurnal change of under water illumination at lake Abashiri in Japan. Limnological studies of Louisiana lakes were studied by Moore (1950). Dissolved Oxygen deficiencies including complete depletion, were found in the lower thermocline and hypolimnion. Investigations on organic chemical compounds in raw and filtered surface water were made by Baraus et. al. (1951). McCombie(1959) studied some relations between atmospheric temperature and the surface water temperature of lakes.

Vigano et. al. (1969) studied the physical and chemical aspects of lake Paterno. Water temperature, pH, dissolved oxygen, hardness and transparency were discussed. Extremely variable physico-chemical environment exhibited by temporary ponds in Oklahoma State, U.S.A. was investigated by Black (1976). Tundisi et. al. (1977) discussed the primary production, standing stock of phytoplankton and ecological factors of a shallow tropical reservoir in Brazil. Measurements made in shallow lakes showed that the temperature variation of the surface water respond significantly to change in solar radiation, water circulation, and substrate colour (Dale and Gillespie, 1977).

Ryabov and Denisova (1978) determined the elements of biogenic and organic substance metabolism in relation to bio-productivity in the Kremenchurg reservoir of U.S.S.R. Jones and John (1978) studied the chemical characteristics of some Missouri reservoirs.

McFarlane et. al. (1979) documented the different water chemistry parameters such as pH, conductivity, chlorides, sulphates, sodium, potassium, magnesium, calcium, zinc, copper, cadmium manganese and iron of a lake at Maritoba, Canada. Edmonds et. al. (1980) illustrated the profundal benthos of a multibasin foot hill reservoir in Colorado, U.S.A. The water showed much seasonal variations in temperature, pH, dissolved oxygen and biotic characteristics. A preliminary limnological

survey of Bufflesport dam has been made by Walmskey and Toerien (1980). Destruction of organic matter in the Rybinsk reservoir, (USSR) was shown by Romenko (1981). Bostroem (1981) studied the factors controlling the seasonal variation of nitrite in lake Erken, Sweden. The seasonal variation of nitrite concentration in this mesotrophic lake was markedly regular and showed some important differences compared with that of phosphate.

Sete et. al. (1982) observed dissolved organic carbon as a controlling factor in oxygen consumption in natural and man-made water. The possible ecological significance and problem of dissolved organic carbon were discussed for the comprehension of the microbial metabolism in the water.

Horn and Wolfgang (1983) showed that the phytoplankton losses were due to zoo plankton grazing in a drinking water reservoir. Campos et. al., (1983) made a limnological study of lake Ranco, its morphometry, physico-chemical factors and plankton. Melack and Thomas (1983) studied diel oxygen variations and their ecological implications on flood-fed, lakes (Amazon river) of Brazil. Influx of oxygen from the atmosphere was a major source of dissolved oxygen. A conspicuous feature of the oxygen content was the erratic variation between periods of positive and negative rates of oxygen change, during both day and night.

Recently, Blazka and Lidmila (1984) studied the amount of organic carbon in a eutrophic fish pond in Czechoslovakia. Khan and Ejike (1984) studied the planktons and water chemistry of Lamingo dam, Nigeria in West Africa.

LIMNOLOGICAL STUDIES IN INDIA

Ganapathi (1949,1955,1959) determined the diurnal variations in dissolved gases, pH and some of the important dissolved substances of biological significance in three temporary pools at Mettur, Tamilnadu. Diurnal variations in two shallow ponds in Delhi were compared by George (1961). Krishnamurthy and Visweswara (1965) extensively studied the ecological and hydrological nature of freshwater system in India.

The limnology of Ramgarh lake was studied by Sahai and Sinha (1969). The variations and inter-relationship between different physical factors, like depth, transparency, water temperature and colour etc., and chemical factors, like, pH dissolved oxygen, free CO₂, alkalinity, chlorides, calcium, nitrates and phosphates were discussed. Temperature, dissolved oxygen, alkalinity, pH, electrical conductivity, calcium, silicate, phosphate, primary production and plankton of Aliyar reservoir, Tamilnadu were studied by Sreenivasan (1970). The physico-chemical and biological factors, of tank water were illustrated by Vijayaraghavan (1971).

Sreenivasan (1974) studied the limnological features of a tropic impoundment of Bhavanisagar reservoir. He reported that the influx of flood water improved the bottom oxygen conditions and methyl orange alkalinity and pH varied with depth diurnally and seasonally. Limnological studies of Kashmir lakes, were carried out by Kant and Kachroo (1975). The primary productivity and physico-chemical factors of two fresh water ponds in West Bengal were clearly pointed out by Mundal (1976).

Sarkar and Natarajan (1977) studied the limnological features of Govindasagar reservoir, Himachal Pradesh. Nasar (1977) studied the physico-chemical properties over the 24 hours in a freshwater pond at Bhagalpur. Sreenivasan (1977) studied the limnological features and fisheries of Tirumoorthy reservoir, Tamil Nadu. He stated that the "Oxygen Curve" was mostly ortho-grade, the water was generally saturated with oxygen to more than 50 per cent making it a good habitat for fish. The organic carbon and nitrogen were fairly high.

Seasonal studies on some of the physico-chemical parameters and Zooplankton were made in a pond at Madurai (Kadar et. al., 1978). Seasonal variations in the physico-chemical factors of a sub-tropical lake of Kashmir were described by Quadri and Yousuf (1978). Kannan and Job (1980) revealed the diurnal and seasonal changes of physico-chemical factors in Sathiar reservoir.

Jayangouder (1980) carried out the hydrobiological studies on the Ajwa reservoir, Uttar Pradesh. Ecology, the fish fauna and physico-chemical conditions of Vellayani lake were well documented by Susheela (1980).

Khan and Zutshi (1981) studied the limnology and primary productivity of the plankton community of Nilnag lake. Observations were made on the abiotic factors and planktonic periodicity in a shallow pond of the highlands of Shillong, (Nasar and Kaur, 1981). Temperature, transparency, dissolved oxygen, free carbon dioxide, alkalinity, calcium, magnesium, pH, phosphate, and nitrogen were determined seasonally in the shallow zones of Nainital lake by Rekha and Singh (1981).

Chowdhury and Mazumder (1982) made a survey of lake Kaptai. Emphasis was given on the seasonal, vertical, horizontal and diurnal fluctuations in some physico-chemical parameters of lake water. The lake was oligotrophic with acidic to near neutral pH and low nitrate and phosphate content. Vertical temperature variation was considerable in summer and thermal stratification seemed to be a definite possibility.

Gopal et. al. (1982) made a limnological study of a fresh water reservoir in Jaipur. Mitra (1982) made a comparative account of the river Godavari, Krishna, Tungabhadra and found that all the rivers have similar physico-chemical characteristics.

Babu et. al. (1983) studied the impact of total solar eclipse on some physico-chemical factors and plankton density in a fresh water pond. The changes in the physico-chemical parameters and plankton density observed under the impact of the eclipse were discussed. Singh et. al. (1983) revealed the seasonal and diurnal variations in physico-chemical conditions of water and plankton from surface and bottom water samples of lotic sector of Rihand reservoir in Uttar Pradesh. Krishnamoorthy (1983) studied the physico-chemical parameters of a natural pond ecosystem. The temperature showed marked fluctuation both in surface and bottom water. Alkalinity showed marked variations. All the nutrients were observed.

Krishnamoorthy (1984) studied the physico-chemical features of the Bhavanisagar reservoir. All the physical and chemical parameters were observed. The surface water temperature was almost similar to that of atmospheric temperature. Alkalinity showed a gradient throughout the study period. The nutrients like phosphate, nitrate, silicate and sulphate concentration were estimated. The values of the nutrients varied from nil value to higher values as 51.25 mg/l, 16.0 mg/l, 8.711 mg/l, 14 mg/l & 44.4 mg/l respectively.

Saha and Pandit (1984) studied the comparative physico-chemical properties of pond and riverine water and indicated that water temperature, carbonate and bicarbonate alkalinity, total hardness, chlorides, sodium, potassium, nitrate nitrogen and total dissolved solids were much higher in pond than those of riverine water, whereas dissolved oxygen, turbidity, silicate and calcium were found to be lesser in ponds which proved clearly that the pond water is more eutrophic than the riverine one.

The diurnal changes in temperature, transparency, free CO₂, dissolved O₂, pH, alkalinity studied by Mathur (1987). Dissolved O₂ was found to vary inversely, pH vary with bicarbonate; alkalinity and chloride was found to be high.

Kumar et. al. (1989) studied seasonal variations in the nutrients like calcium, magnesium, phosphate, silicate, nitrate, organic carbon and iron.

Bohra (1990) studied the seasonal variations in the physico-chemical conditions of a freshwater pond known as "Raju Dighi" at Barharwa (Bihar). Atmospheric temperature (29.1° C to 32.1° C) water temperature (24.5° C- 29.8° C), pH (6.8-6.9) dissolved oxygen (5.12 ppm to 6.20 ppm) and free carbon di oxide (1.2 ppm to 1.4 ppm) showed slight variation during different seasons. Bicarbonate alkalinity (50 ppm-60 ppm) was observed higher in summer whereas carbonate alkalinity was absent during the study period.

Seasonal variations in physico-chemical parameters were carried out by Ahmed and Krishnamoorthy (1990). The physico-chemical variables studied were atmospheric temperature, water temperature, humidity, dissolved oxygen, oxidisable organic matter, pH, bicarbonate, chloride, sulphate, total nitrogen, phosphate and total solids. An analysis of the seasonal variations of ciliates was carried out in relation to the selected physico-chemical variables.

The physico-chemical features of Swamps of Libri river, Purnia were investigated by Ponday et. al. (1993) to evaluate their roles in the yield of air breathing fishes. Relatively high temperature, high value of dissolved oxygen and highest productive range of alkalinity were observed which were favourable factors for the production of air breathing fishes.

Ecological study on Govindgarh fresh water lake of Rewa was conducted during 1990-91 by Tripathi et. al. (1993). Temperature and pH of water samples fluctuate within narrow ranges. The fish fauna of the lake was adversely affected due to high turbidity and low O₂ content during the summer season. Many fishes were found floating and gasping for air, Phytoplankton and zooplankton were moderately present throughout the year. If the ecological conditions with refernce to O₂ availability were maintained during the summer season also, this lake with its abundant fish pond food organisms could be well managed to yield more fishes.

Joshi and Bishtres (1993) studied the physico-chemical parameters of the water of Ganga Canal near Jwalpur at Hardwar. The turbidity values showed more (17.75 per cent) variation & pH value showed minimum (8.86 per cent) variation.

Mahajan and Kanhere (1995) studied a pond at Barwani, M.P. and found transparency (8.2 to 32 cm), alkaline pH, dissolved oxygen content varying from 6.9 to 8.3 mg/l, phosphate in the range of 0.1 to 2.2 mg/l and relatively high level of solids. This water was found suitable for fish culture.

A synchronous study of physical and chemical properties of the Bhavani river at Thekkampati was made for one year (from August 1993 to July 1994) for the first time by Saradhamani and Sivakumar (1995). Changes in the values of nutrients of the river were correlated with the corresponding physico-chemical parameters. It was found that as the river Bhavani had a very high saturation of oxygen and nutrients, it could be utilized for aquaculture practices.

The abiotic factors of irrigation tanks Dharwad, Karnataka indicated their suitability for pisciculture and agriculture uses. The biotic disturbances influenced the increase in dissolved salts (Hegde and Kale, 1995).

Diel fluctuations in water temperature, pH, conductivity, total dissolved solids (TDS), free CO₂, dissolved oxygen (D.O.), total alkalinity, total hardness and chloride from eight different sampling stations of the Ganga river water (Rishikesh to Kanpur) were studied by Sahu et. al.(1995) and they reported that free CO₂ concentrations during night time at Narora, Kachlaghat, Farrukabad and Kanpur had crossed the tolerance limit prescribed for fish culture.

After reviewing the literature in the field of limnology the present study was undertaken to study the physico-chemical parameters of a rain-fed tank at Kurichi in Coimbatore and the suitability of the water for domestic, irrigation and pisciculture practices.

Methodology

MATERIALS AND METHODS

For the present study, water samples were collected from Kurichi Tank, situated in the South side of Coimbatore, 3km away from the city. It is a perinneal tank fed by south west monsoon. It is about 2880 metres in length and 1600 metres in width and 3.225 metres deep. The water spread area of the tank is hectares 139.27122. (Fig.1 and 1a). The total capacity of the tank is 60 metric cubic feet. The tank has maximum water column during south west monsoon (May to July) and reaches its minimum level during February to April. This water is mostly used for bathing, washing, irrigation and also for pisciculture.

COLLECTION OF WATER SAMPLES:

Samples were collected from the Kurichi tank at an interval of 15 days, for a period of 3 months (from November 1995 to January 1996), so that totally six times water samples were collected for analysis. In order to maintain uniformity, care was taken to collect samples at 10 a.m. during each collection.

Water samples were collected from the tank in clean plastic containers to test the various physico-chemical parameters. To estimate oxygen content, water was collected in reagent bottles. The water was allowed to over flow and stoppered immediately. Water for iron estimation was collected in a small glass stoppered bottles containing α - α bipyridyl solution to prevent the oxidation of ferrous iron to ferric state.(Fig.2). During these collections, the temperature of water was determined using a thermometer.

ANALYSIS OF WATER SAMPLES:

Using Standard Methods (APHA, 1975), the following parameters were analysed.

PHYSICAL PARAMETERS:

COLOUR

The colour of the sample was visually observed.

ODOUR

The odour of the sample was noted by directly smelling the sample.

TURBIDITY

The turbidity was estimated by Jackson Candle method and was presented as number of Jackson turbidity units.

TEMPERATURE

Temperature was measured at the sampling station itself, using mercury filled centigrade thermometer (0° to 50°C). The readings were made by dipping the thermometer in water for 2 minutes before constant readings were obtained.

CHEMICAL PARAMETERS:

pH

A direct reading pH meter was used.

The electrodes were washed with distilled water and wiped dry with tissue paper or cotton. The pH meter was standardized by immersing the electrodes in the buffer solution of pH 7.0. The temperature control scale was set as per the temperature of the solution.

The function selector in the pH mode was pressed. The pH LED glowed. The pH meter gave a reading near 7.0 (If the pH is 6.8 the "standardize" control was used to make the reading exactly 7.0).

The buffer solution of pH 7.0 was removed and the electrodes were washed and dried as instructed earlier. Then the electrodes were dipped in the buffer solution of pH 4.0. In the digital display if the buffer solution of pH was more than 4.0, the slope control (at the back of the instrument) was used to adjust the pH reading to 4.0.

Now the pH meter was standardized and left without any disturbance. Again the electrodes were rinsed in distilled water. Then they were immersed in the water sample. The reading was noted in the digital display. The same procedure was repeated with the other samples and the corresponding pH values were recorded. The check switch was pressed and the display was read. If there was any accidental movement and if the reading was different from the one noted earlier, it was set right by using the "standardize" control.

DISSOLVED OXYGEN

Dissolved oxygen was estimated by Winkler's method.

CARBON DIOXIDE

100 ml of water sample was taken in the conical flash. 2-3 drops of phenolphthalein was added as indicator. This solution was titrated against 4 per cent NaOH solution taken in a burette. The end point is the appearance of permanent pale pink colour. Titration was repeated for concordant value. The same procedure was followed for the other samples.

CONDUCTIVITY

Electrical conductivity was estimated by a direct reading conductivity meter and was presented in micro mhos/cm (reciprocal megaohms/cm³).

TOTAL SOLIDS

A known volume (250 ml) of the sample was taken in a pre-weighed silica crucible and the sample was evaporated to dryness using a water bath. After complete evaporation the final weight of the crucible was taken. The total solids present in the sample was calculated by using the following formula.

Calculation

$$\text{Total solids (mg/l)} = \frac{(\text{Final} - \text{Initial}) \text{ weight of crucible} \times 1000}{\text{Volume of the sample}}$$

SUSPENDED SOLIDS

Suspended solids of the sample was estimated by centrifugation method.

50 ml of the sample was centrifuged and after centrifugation the residue was washed with distilled water, recentrifuged and the suspended solids in the centrifuge tube was transferred to a pre weighed silica dish and dried at 105°C. The increase in weight was equal to the amount of dissolved solids.

ESTIMATION OF ALKALINITY

Phenolphthalein alkalinity was estimated with the help of a titrating method against 0.02N sulphuric acid using phenolphthalein as indicator (0.1 per cent alcoholic solution).

After finding phenolphthalein alkalinity, methyl orange alkalinity (total alkalinity) was estimated by continuing the same titration, adding methyl orange as indicator.

Calculation

$$\text{Phenolphthalein alkalinity (CaCO}_3\text{) mg/l} = \frac{\text{ml. of 0.02N H}_2\text{SO}_4 \text{ for Phenolphthalein end Point} \times 1 \times 1000}{\text{ml. sample taken for titration}}$$

$$\text{Total alkalinity as (CaCO}_3\text{) mg/l} = \frac{\text{ml. of 0.02N H}_2\text{SO}_4 \text{ for total alkalinity end point} \times 1 \times 1000}{\text{ml. sample taken for titration}}$$

ESTIMATION OF HARDNESS

Total hardness of the sample was estimated by EDTA Titrimetric method

i. Carbon and non-carbonate hardness

Carbonate and non-carbonate hardness were estimated using the below mentioned formula.

When the hardness is numerically greater than the sum of bicarbonate and carbonate alkalinity (methyl orange alkalinity), the amount equal to the alkalinity is carbonate hardness and the excess amount is non-carbonate hardness.

$$\text{Carbonate hardness} = \text{Alkalinity}$$

$$\text{Non-Carbonate hardness} = \text{Total hardness} - \text{Alkalinity}$$

If the hardness is equal to or less than the sum of the carbonate and bicarbonate alkalinity all the hardness is carbonate hardness and there is no non-carbonate hardness.

$$\text{Carbonate hardness} = \text{total hardness}$$

$$\text{Non-carbonate hardness} = 0$$

ii. Calcium and Magnesium hardness

Calcium hardness was estimated by EDTA Titrimetric method.

Magnesium hardness - Total hardness - Calcium hardness

IRON

Iron in the sample was estimated by α - α Bipyridyl method.

1.0, 2.0, 3.0, 4.020.0 ml of standard ferrous solution were taken in a series of 100 ml volumetric flasks. To each flask 1 ml of hydroxylamine hydrochloride solution and 10 ml of α - α bipyridyl solution were added and mixed well. After 10 minutes, 2 ml of sodium acetate buffer solution was added and made up to 100 ml with distilled water. 2 drops of ethylene diamine reagent was added and mixed thoroughly. The sample was collected in a bottle containing 5 ml of α - α bipyridyl solution. Then 5 ml of acetate buffer solution was added. The colour of the sample was compared with that of the prepared standards.

SILICATE

11 Conical flasks of 100 ml capacity were taken and numbered. 50 ml of distilled water was taken in the first flask and was treated as blank. In the remaining conical flasks 1 ml, 2.5 ml, 5 ml, 10 ml, 20 ml, 25 ml, 30 ml, 35 ml, 40 ml and 50 ml of potassium chromate solution was added and diluted to 50 ml with

distilled water. The colour intensity was found out with the colorimeter at 420 nm. The standard graph was drawn by plotting the concentration of standard solution on the X-axis and O.D. value on the Y-axis.

50 ml of the tank water was taken. 2 ml of 1:1 HCl was added to it. It was shaken well and left aside for 5 minutes. Then 1 ml of oxalic acid was added and left to stand for 10 minutes, following which 2 ml of ammonium molybdate was added. After sometime the yellow colour developed in the sample was measured using colorimeter at 420 nm.

The amount of silicate in the water sample was calculated by referring to the standard graph and was expressed as mg/l. The same procedure was followed for the other water samples.

MAGNESIUM

Appropriate volumes of magnesium standard solution were taken in 100 ml volumetric flasks and diluted to 50 ml with distilled water. A 100 ml volumetric flask containing 50 ml distilled water was used as the blank. The sample was taken in a 100 ml standard flask and diluted to 50 ml with distilled water, 1 ml of 0.2N sulphuric acid, 20 ml of calcium sulphate solution and 5 ml of aluminium sulphate solution were added to the blank,

standards and sample. The volume in each flask was made up to 80 ml with distilled water. 5 ml of stabilizing solution, 2 ml of brilliant yellow solution and 3.5 ml of sodium hydroxide solution were added to the flasks and the solution was made up to 100 ml with distilled water. The colour developed after 5 minutes was read in a colorimeter against 525 nm.

CALCIUM

50 of the sample was taken in a conical flask and diluted to 100 ml with distilled water. 4 ml of sodium hydroxide solution was added and pH was adjusted to pH 12.0. 1-2 drops of indicator solution (ammonium purpurate) was added. The solution was titrated with EDTA to get the end point. Calcium in the sample was calculated using the following formula.

$$\text{mg/l Calcium as Ca} = \frac{\text{ml.EDTA titrant} \times 1 \times 1000}{\text{ml.sample taken for titration}} \times 0.40$$

CHLORIDE

100 ml of sample was taken in conical flask. 1 ml of potassium chromate indicator solution was added and was titrated against 0.0282N silver nitrate solution until the appearance of perceptible reddish colour. 100 ml of distilled water as blank was taken in a conical flask and the same procedure was followed.

Calculation

$$\text{mg/l Chloride as Chlorine} = \frac{\text{ml. AgNO}_3 \text{ solution for sample} - \text{ml. AgNO}_3 \text{ solution for blank} \times 1000}{\text{ml. sample taken for estimation}}$$

NITRATE

Nitrate in the sample was estimated by Brucine method.

0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 ml of nitrate standard solution were taken in a series of 50 ml beakers and diluted to 5 ml with distilled water. A beaker containing 5 ml of distilled water was used as the blank. 2 ml of the sample was taken in a 50 ml beaker and diluted to 5 ml with distilled water. 1 ml of brucine sulphanilic acid solution was added to the blank, standards and sample and mixed well.

10 ml of sulphuric acid solution was taken in a second series of 50 ml beakers. The contents of the first series of beakers were poured into each of the second series of beakers and mixed well. Beakers were kept in the dark for 10 minutes.

10 ml of distilled water was added to all the beakers. Beakers were allowed to cool for 20-30 minutes. The colour developed was read in a colorimeter against 510 nm. Using the calibration curve the mg. equivalent of nitrate nitrogen in the sample was found out.

SULPHATE

200 ml of the sample was taken in a 500 ml beaker and diluted to 400 ml with distilled water. pH was adjusted to 4.5 - 5.0 with HCL using methyl red indicator (to orange colour). The solution was allowed to boil for 1 minute and 10 ml of hot barium chloride was added with constant stirring. The beaker was kept on a water bath at 80° - 90°C for 2 hours to digest the precipitate. The contents of the beaker were filtered and washed with hot water. The filter paper with the precipitate was taken in a weighed silica crucible and heated in low flame, until the paper was charred. After the charring it was ignited at 800°C for 1 hour.

Calculation

$$\text{mg/l Sulphate as SO}_4 = \frac{\text{mg. BaSO}_4}{\text{volume of the sample in ml.}} \times 411.5$$

SKETCH SHOWING THE KURICHI TANK
IN S. NO: 131 KURICHI VILLAGE

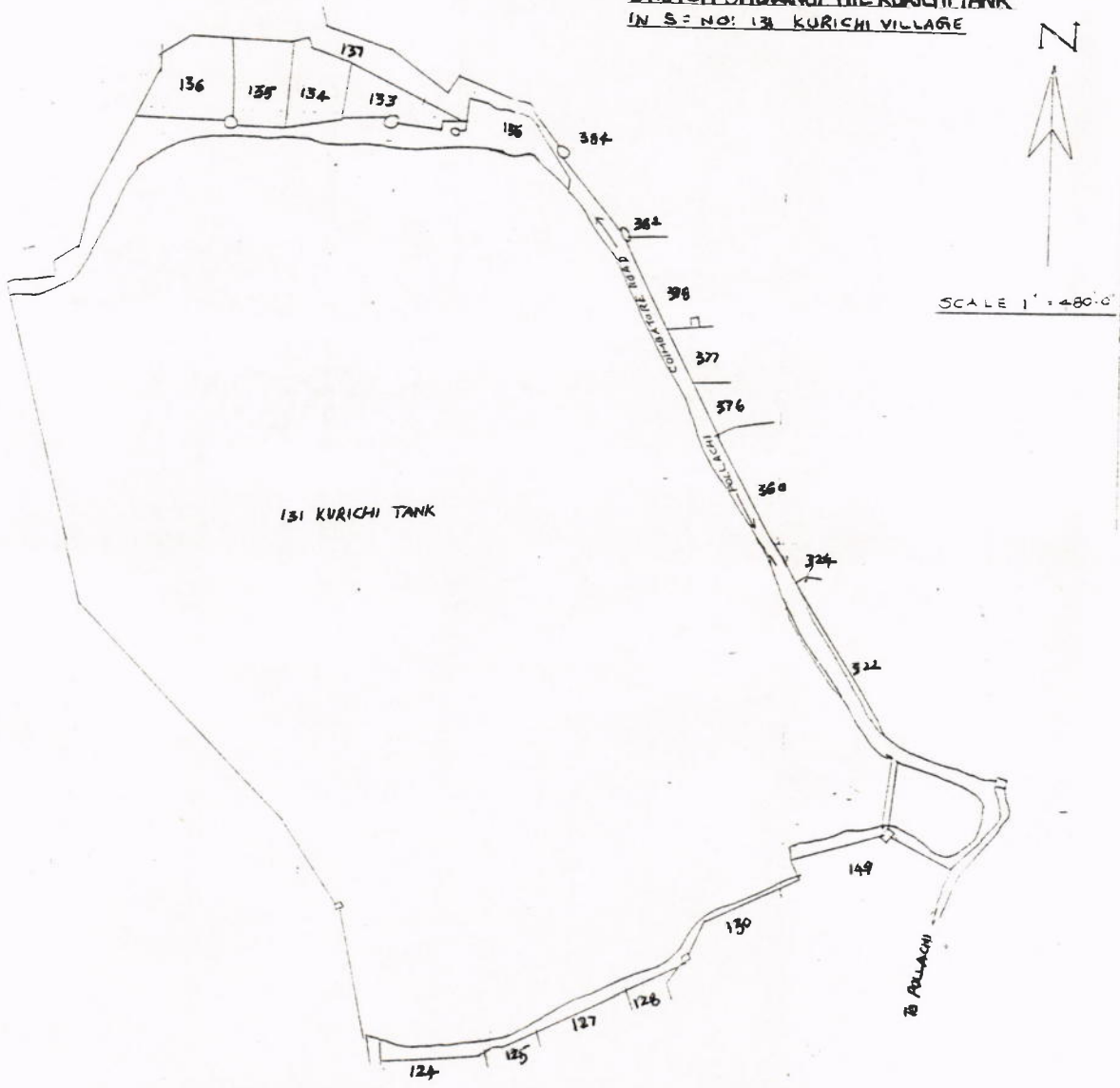


Fig. 1



Fig.1a Water spread area of the tank.



Fig.2 Plastic container and bottles used for collecting water samples, for testing the various physico-chemical parameters.

Results And Discussion

RESULTS AND DISCUSSION

In the present study the physical and chemical parameters of the tank water were analysed during the winter months of November, December and January. The physical parameters observed were colour, odour, turbidity and temperature. The observations were presented in Table I. The chemical parameters of the tank water analysed include pH, dissolved oxygen, carbon dioxide, conductivity, total solids, alkalinity, iron, silicate, magnesium, calcium, hardness, chloride, nitrate and sulphate. The results were given in Table II and III.

PHYSICAL PARAMETERS

Water samples were found to be colourless throughout the course of study.

Colour is a common constituent of natural water. It is caused by metallic substances such as iron and manganese compounds, humus materials, peat, tannins, algae, weeds, and Protozoans. An undesirable appearance is produced by colour in water. The determination of colour is rapid and is useful in detecting a change in character of the water. Industrial effluents also contribute colour to water.

Water samples were found to be odourless throughout the course of study.

No water can be quite satisfactory for domestic and industrial purposes if it possess any odour. The usual requirement of water sample is that they should not contain any objectionable odour.

Turbidity of the tank water was observed to vary between 40 and 60 JTU (Jackson Turbidity Units). The average turbidity was 51.666 ± 6.871 .

Turbidity is the most important physical parameter associated with the satisfactory appearance of the water samples. The cloudy appearance developed in water due to turbidity is aesthetically unattractive.

In the present study turbidity of the water was found to be within the limits prescribed for natural water.

All the natural water contain suspended materials and therefore all are turbid, although they vary in the amount (Welch,1952). The term turbidity is applied to water containing suspended matter that interferes with the passage of light through it, range being between 30 and 100 mg/l (Rao and Mahmood,1995).

In the present study the temperature was measured for the surface water. Since the work was carried out during winter months the duration of sunshine was lesser and air temperature was lower. The temperature of the surface water ranged between 26°C to 28°C with an average of 27°C \pm 0.632.

During the month of November the temperature recorded was 27°C. In the beginning of December the temperature was 27°C and had fallen to 26°C by the end of December. In January the temperature was raised to 27°C and then to 28°C.

The surface water temperature is almost similar to that of atmospheric temperature (Macon, 1958). The minimum surface water temperature was observed during December, and the same was reported by Sreenivasan (1977). This may be due to high humidity in the atmosphere during that month.

The observations made by Krishnamoorthy et. al. (1976) showed that the lowest temperature was recorded during November to January months. The temperature ranging between 22°C to 34°C in winter was also recorded by Verma et. al. (1978).

CHEMICAL PARAMETERS

pH of the water ranged between 8.2 to 8.7 depicting alkaline conditions throughout the study period. Similar pH range for natural water was observed by different workers.

The alkaline nature of tank water (pH 7.3 to 8.2) was observed throughout the study period by George et. al. (1986). Saha and Chowdhary (1985) obtained maximum pH of 8.4 in January and minimum of 7.3 in August. Bhatt and Negi (1985) observed a pH range of 7.2 to 8.2 for natural water. The alkaline nature of the water (pH 8.0 to 9.6) was observed all around the year by Rao and Mahmood (1995), the values being lower in summer and higher in rainy and winter seasons. The pH between 7.0 and 9.5 was observed by Krishnamoorthy et.al. (1976). All these studies were in accordance with our observation.

The alkalinity may be due to the presence of bicarbonates as suggested by Mitra (1982) and Georgr et.al. (1986).

The values for dissolved oxygen ranged between 6.7 and 6.9 mg/l and the average was found to be $6.8 + 0.089$. Similar mean value for dissolved oxygen ranging between 6.8 to 7.3 mg/l for river water was reported by Rao et. al. (1990). Dissolved oxygen values in the same range were recorded during the winter months of November, December and January by Rao and Mahmood (1995), Saradhamani and Sivakumar (1995), Swain et. al. (1994), Bhatt and Negi (1985) and Ahmed and Krishnamoorthy (1990). Oxygen is dissolved in water in varying concentrations and the solubility of oxygen depends on temperature, pressure and salinity of water.

The present study observed the absence of free carbon-dioxide in the tank water. Our observation is found to be in agreement with that of Sahu et. al. (1995) who had observed the level of free carbon dioxide varying from 0.00 to 13.20 mg/l for Ganga river water.

The present finding of free Carbon dioxide below the detectable levels was similar to the findings of Ghosh et.al. (1974) and Cola (1979).

Electrical conductivity of the tank water ranged between 250 micro mhos/cm and 300 micro mhos/cm. The maximum was recorded in the month of January. Since conductivity varies directly with the temperature of the sample the result is usually reported at 20°C. Electrical conductivity of almost the same range was observed for river water by Mahadevan and Krishnaswamy (1983). Similar reports were made by Mahajan and Kanhere (1995) for pond water.

Total solids of the tank water ranged between 192 to 220 mg/l with the mean value of 209.3 ± 10.385 . It was observed that the suspended solids of the tank water ranged between 28 to 40 mg/l with the mean value of 33.8 ± 4.490 . The value for the dissolved solids of the tank water was found to be between 161 to 187 mg/l with the mean value of 175.5 ± 11.220 .

Total dissolved solids ranging from 69 to 226 mg/l was obtained for Ganga river water by Sahu et. al. (1995). Suspended solids in the range of 18 to 60 mg/l was obtained for river water by Saradhamani and Sivakumar (1995). Similar trend was noted for river water by Khatavkar and Trivedy (1992) and by Mahajan and Kanhere (1995) for pond water.

The hardness of the water ranged between 95 to 120 mg/l and was found to be due to carbonate hardness. The values for total hardness in the same range were obtained for pond water by Rao and Mahmood (1995) and by Hegde and Kale (1995) for water from a irrigation tank.

The hardness is the soap destroying power of water. The carbonate hardness is the temporary hardness and is mainly due to the presence of bicarbonates of calcium and magnesium. The non-carbonate hardness is the permanent hardness and is due to the presence of sulphates, chlorides and nitrates of calcium and magnesium. It requires special treatment of water softening.

Alkalinity values of the tank varied between 106 to 138 mg/l. Similar values for natural water were given by Saradhamani and Sivakumar (1995), Sahu et.al.(1995) and Mahadevan and Krishnaswamy (1983). The alkalinity of the tank water was found to be due to the presence of bicarbonates of calcium and magnesium.

NUTRIENTS

The maximum silicate value recorded was 15 mg/l and the minimum value recorded was 5 mg/l. The concentration of calcium and magnesium ranged between 22.4 to 32.4 mg/l and 6.24 to 13.44 mg/l respectively. The amount of chloride in the tank water was found within the range of 12 to 16 mg/l and the concentration of sulphate from 8-15 mg/l. The level of nitrate varied between 0.0- 0.5 mg/l.

The salt concentration in the water is similar to that of many freshwater systems studied by earlier workers. The values of calcium, magnesium, silicate, sulphate and chloride were found similar to those observed for river water by Mitra (1982). Agarwal et.al. (1976) observed nitrate values ranging from 0.00 - 0.2 mg/l with the mean value of 0.022 mg/l and chloride values ranging from 18.0 - 45.0 mg/l. The chloride values in the same range was reported by Khatavkar and Trivedy (1992). The calcium values ranging from 25.2 to 61.0 mg/l was reported by Saradhamani and Sivakumar (1995).

Mostly in natural water iron concentration is either negligible or less than 1 mg/l. Negligible quantities of iron in water samples were reported by Rao and Mahmood (1995). and Rao et.al. (1990). Chloride in the range of 12-16 mg/l was reported by Mahajan and Kanhere (1995). The low content of nitrate in

pond water was noticed by Mahajan and Kanhere (1995). Sreenivasan (1974) reported the absence of nitrates and trace amounts of inorganic phosphates in the Bhavani Sagar reservoir.

Calcium is one of the principle cations in natural water. The concentration of magnesium in the tank water was found to be lower than that of calcium, in accordance with the natural abundances of these two elements in rocks/minerals. The same relationship between the concentration of magnesium and calcium in river water was reported by Mitra (1982).

Since the tank is mainly fed by monsoon, the nutrients may be added to the water, washed from adjacent soil as suggested by Sharma et.al.(1978), Chowdhry (1981) and Mazumder (1981).

QUALITY OF WATER

Water quality standards varies with different uses. Water quality is an objective variable and the suitability of water for any specific use is user's prerogative.

Water quality is expressed in terms of variables such as physical, chemical and biological. In the present study water quality was assessed in terms of physical and chemical parameters.

QUALITY FOR DOMESTIC USE

Water is essential for many domestic uses such as drinking, cooking, washing, etc. The Kurichi tank water is used for washing and bathing (Fig.3 and Fig.4). One of the methods followed in finding the suitability of water for this purpose is to classify them on the basis of hardness given in table IV. In the present study the hardness of water during the winter months of November, December and January was found to vary between 90 to 120 mg/l. This shows that the water is only slightly hard and quite suitable for washing and bathing.

QUALITY FOR IRRIGATION

The tank water is used for the cultivation of vegetable crops and greens (Fig.5). Generally the suitability of water for irrigation purpose is based on its mineral contents. According to Wilcox, the water samples for irrigation purpose are classified on the basis of percent sodium and electrical conductivity. But in the present study the water quality was assessed based on electrical conductivity (Table V). In the present study the Kurichi tank water does not appear to pose any problem as its quality ranges between the classes, the excellent and good.

Since electrical conductivity is a good measure of dissolved salts, U.S. Salinity Laboratory has made the grouping of water as shown in table VI. The results have shown the suitability of the water for irrigational purpose.

AESTHETICS

The criteria for the aesthetic quality can best be described qualitatively. The surface water should be free of floating debris, scum and oil; objectionable organoleptic features of colour, odour and taste should not be present (Berkson, 1974). From general observations it can be seen that the water conforms to these standards.

QUALITY FOR FISH GROWTH

In the development of fisheries of inland water surface water plays an important role. The tank which has alkaline pH, dissolved oxygen content in the range of 6.7 and 6.9 mg/l, relatively high solid levels, negligible amount of nitrates, and iron in trace amounts make it suitable for fish growth. Since the tank has relatively high levels of nutrients in winter, it is believed that the tank may be enriched with nutrients during the rainy months, making it more suitable for fish growth.

Some important inland water food fishes are grown in the tank and they include Catla catla, Ophiocephalus striatus, Tilapia mossambica, Labeo rohita and Mystus sp. The fingerlings of these varieties are introduced in to the tank in August after south west monsoon (May to July) and are harvested in March and April, when the water column reaches its minimum level.

Catla catla

Catla is the largest Indian carp, attaining a maximum length of about a metre and is found through out India. Its body is broad, deep and stout. Dorsal profile is more convex. Head is large with prominent lips. Colour is blackish gray above and silvery on the sides (Fig.6). It is drawing its nutrition from detritus and semi decayed vegetable matter.

Ophiocephalus striatus (Tamil-Virahl)

Body is elongated, anteriorly cylindrical and posteriorly compressed. They are medium sized fishes. Body is dark brown or black above, yellowish or orange below. They prefer stagnant muddy water and feed on worms, insects, tadpoles, frogs, fries, and fingerlings of fishes. Eating the young ones of its own race is also common. This species is esteemed for its food value (Fig.7).

Tilapia mossambica

It is an exotic fish brought to Mandapam, India for the first time in 1952 from Bangkok. Now it is well spread, naturalized and established like any other indigenous fish (Fig.8).

It grows to a maximum length of about 36 cm and gains a total weight of up to 850 gm in one year time. It is advantageous over many other fishes because it feeds on any kind of available food material either natural or artificial feeds (plants and animal matter); matures quickly in 2 to 3 months; breeds naturally and frequently. It is suited for various culture practices of the present day such as polyculture, paddy-cum-fish culture, sewage fish culture and mixed farming practices along with pig and duck rearing.

Labio rohita (Tamil - Rohu)

It has a spindle shaped body, measuring up to one meter in length and weighing about 20-25 kg. Body is yellowish in colour. Mouth is sub terminal. It is a detritus feeder (Fig.9).

Mystus sp.

Body is moderately elongated. Head is depressed and flattened ventrally. There are four pairs of barbels. There are two dorsal fins. They are predaceous and often called as weed fishes. They are considered to be very delicious (Fig.10).

In general water from Kurichi tank appears good for washing and bathing, for the cultivation of vegetable crops and greens and also for fish growth. However, due to biotic disturbances like excessive cattle bathing (Fig.11) and washing of clothes, the quality of water may deteriorate to some extent.

Cattle bathing is common in the tank. The activities of washer men on the western bank also bring in certain amounts of detergents in to the tank through out the year. Since the corporation water supply is limited in Kurichi area, the people mostly depend on the tank water for washing and bathing. In addition the tank fed by monsoon, provides water for irrigation and a suitable medium for fish growth and hence its judicious use is imperative.

TABLE I

Physical parameters of the tank water during the winter months of November, December and January.

S.No.	Parameters	November		December		January		Mean value
		1	2	1	2	1	2	
1.	Colour	Colourless		Colourless		Colourless		Colourless
2.	Odour	Odourless		Odourless		Odourless		Odourless
3.	Turbidity (Jackson Turbidity Unit)	50	50	40	50	60	60	51.666 ± 6.871
4.	Temperature (°C)	27.00	27.00	27.00	26.00	27.00	28.00	27 ± 0.632

Table II

Chemical parameters of the tank water during the winter months of November, December and January.

S.No.	Paramers	November		December		January		Mean value
		1	2	1	2	1	2	
1.	Hydrogen ion concentration (pH)	8.7	8.4	8.4	8.6	8.2	8.2	8.4 ± 0.204
2.	Dissolved Oxygen(mg/l)	6.8	6.9	6.9	6.8	6.7	6.7	6.8 ± 0.089
3.	Free Carbon-dioxide(mg/l)	-	-	-	-	-	-	-
4.	Electrical conductivity (micro mhos/cm)	250.0	260.0	260.0	280.0	300.0	300.0	275.0± 21.679
5.	Total solids (mg/l)	202.0	192.0	215.0	215.0	220.0	212.0	209.0± 10.385
6.	Suspended solids(mg/l)	40.0	31.0	28.0	32.0	38.0	34.0	33.0 ± 4.490
7.	Dissolved solids(mg/l)	162.0	161.0	187.0	183.0	182.0	178.0	175.5 ± 11.220
8.	Total hardness as CaCO ₃ (mg/l)	95.0	112.0	117.0	119.0	120.0	115.0	113.0 ± 9.273
i.	Carbonate hardness as CaCO ₃ (mg/l)	95.0	112.0	117.0	119.0	120.0	115.0	113.0 ± 9.273
ii	Non-Carbonate hardness as CaCO ₃ (mg/l)	0	0	0	0	0	0	0
iii	Calcium hardness as CaCO ₃ (mg/l)	69.0	56.0	74.0	75.0	81.0	72.0	71.166± 8.424
iv	Magnesium hardness as CaCO ₃ (mg/l)	26.0	56.0	43.0	44.0	39.0	43.0	41.833± 9.662
9.	Total alkalinity (mg/l)	106.0	126.0	127.0	136.0	138.0	133.0	127.7 ± 11.639
i.	Phenolphthalin alkalinity(mg/l)	5.0	9.0	12.0	6.0	0	0	8.0 ± 3.162

Table III

Nutrients of the tank water during the winter months of November, December and January.

S.No.	Parameters	November		December		January		Mean value
		1	2	1	2	1	2	
		1.	Silica as SiO ₂ (dissolved) (mg/l)	5.0	15.0	15.0	10.0	
2.	Total iron(mg/l)	1.0	2.0	2.0	2.0	2.4	3.0	2.0± 0.653
3.	Calcium as Ca (mg/l)	27.6	22.4	29.6	30.0	32.4	28.8	28.46± 3.369
4.	Magnesium as Ca (mg/l)	6.24	13.44	10.32	10.56	9.36	10.32	10.04± 2.319
5.	Chlorides as chlorine (mg/l)	12.0	13.0	14.0	15.0	15.0	16.0	14.1± 1.471
6.	Sulphates as SO ₄ (mg/l)	20.0	8.0	15.0	25.0	15.0	13.0	16.0± 5.865
7.	Nitrate nitrogen (mg/l)	0.5	0	0.2	0	0	0	0.35± 0.212

Table IV

Classification of lentic water based on hardness

S. No.	Hardness as Ca Co ₃ (mg/l)	Water Quality
1.	<50	Soft
2.	50-100	Moderately soft
3.	100-150	Slightly hard
4.	150-200	Moderately hard
5.	200-250	Hard
6.	>250	Very hard

Table V

Classification of lentic water based on Wilcox (1955)

Water class	Percent Sodium	EC micro mhos
Excellent	<20	<250
Good	20-40	250-750
Permissible	40-60	750-2000
Doubtful	60-80	2000-3000
Unsuitable	>80	>3000

Table VI

Mineral classification of lentic water based on Electrical Conductivity.

S. No.	Electrical conductivity in micro mhos	class
1.	<250	Excellent
2.	250-750	Good
3.	750-2250	Permissible
4.	2250-5000	Unsuitable



Fig.3 Washermen engaged in washing towards the western-bank of the tank.



Fig.4 Men and Women bathing in the tank.



Fig.5 Vegetable crops and greens grown near the tank, utilizing the tank water.



Fig.6 Catla catla



Fig.7 Ophiocephalus striatus (Tamil-Virahl).



Fig.8 Tilapia mossambica

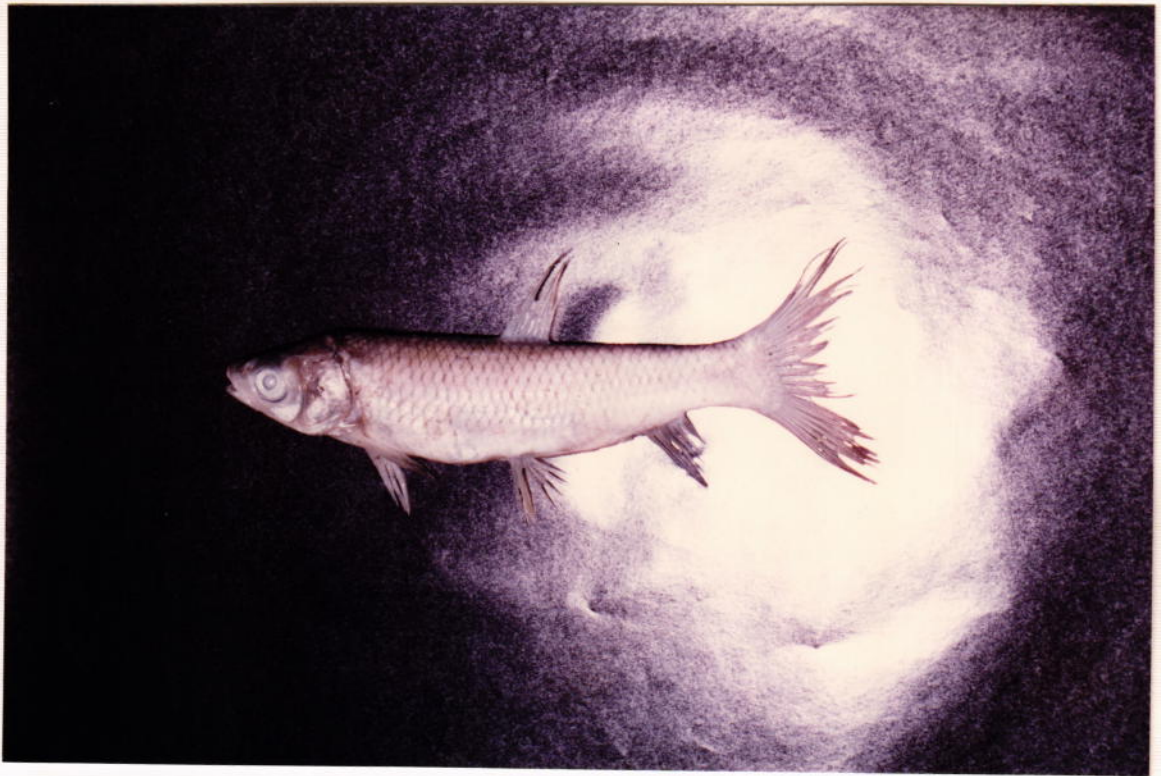


Fig.9 Labio rohita (Tamil-Rohu).



Fig.10 Mystus sp.



Fig.11 Cattle bathing in the tank.

Summary And Conclusion

SUMMARY AND CONCLUSION

1. The present study was undertaken to study the physico-chemical parameters of a rain fed tank at Kurichi, Coimbatore district and the suitability of the water for domestic purpose (washing and bathing) irrigation and pisciculture.
2. It is a perennial tank, in the southern part of Coimbatore, 3 kms away from the city.
3. The water is used for washing, bathing, irrigation and pisciculture.
4. The physico-chemical parameters were analyzed using standard Methods (APHA, 1980).
5. The water samples were collected at an interval of 15 days, during the winter months of November, December and January.
6. The physical parameters of colour, odour, turbidity and temperature were observed.
7. The chemical parameters analyzed include pH, D.O, free carbon dioxide, electrical conductivity, total solids, alkalinity and the nutrients such as iron, silicates, calcium, magnesium, chlorides, nitrates and sulphates.

8. The tank water was colourless and odourless through out the study period. The turbidity was found to vary within the limits prescribed for natural water. The surface water temperature was found almost similar to that of atmospheric temperature.
9. pH of the water ranged between 8.2 to 8.7 depicting alkaline conditions through out the study period.
10. The values of dissolved oxygen ranged between 6.7 to 6.9 mg/l and electrical conductivity ranged between 200 micro mhos/cm to 300 micro mhos/cm
11. The absence of free carbon dioxide in the tank water was observed.
12. The values for total solids, dissolved solids and suspended solids were found to be similar to those obtained for river water by earlier workers.
13. The hardness of the water was found to be due to carbonate hardness. The carbonate hardness is temporary hardness due to the presence of bicarbonates of calcium and magnesium.
14. The alkalinity may be due to the bicarbonates.

15. The concentration of various nutrients estimated for tank water were found to be similar to the values observed for natural water, especially river water.
16. The tank has relatively high levels of nutrients. Among the nutrients the concentration of calcium is higher. The concentration of magnesium is lower than that of calcium, in accordance with their occurrence in nature.
17. The tank has negligible quantities of nitrates and iron in trace amounts.
18. The water quality was assessed in terms of its physical and chemical parameters.
19. Water quality standards vary with different uses.
20. Water quality was assessed based on certain specific parameters such as hardness, electrical conductivity and minerals.
21. In the present study the tank water was found suitable for different uses - domestic (washing and bathing), irrigation and fish growth.

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