Global Journal of Environmental Research 5 (1): 39-45, 2011
ISSN 1990-925X

Impact of Municipal Waste on the Water Quality of River Palar, Tamilnadu, India

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Abstract: The present study was designed to assess the nature, physico-chemical variables and heavy metal pollution from the sewage outfall, industrial wastes and anthropogenic inputs in and around the Vellore town. Three stations, one at Palar inlets, Sathuvachary and Vellore town were selected. Nutrient levels were high at all the stations, especially the Palar enter. High concentration of Cu, Zn, Mn, Cr, Pb and Cd ($\mu g\ l^{-1}$) recorded as 58.90, 5.00, 310.00, 0.690, 6.90 and 13.00 respectively at station 3 while, Cu (34.50), Mn (125.00) Cd (9.00) at station 1, Mn (96.50), Cr (0.45) Pb (4.50) at station 2 were recorded. Further, these stations contribute more concentration of heavy metals when compared to the BSI permissible limits. Moreover, the studies involve the physico-chemical analysis of various parameters such as, Ca, Mn, Na, K, NH_3, Cl, Fl, SO_4 etc. These results shown from the direct discharge of sewage in Palar River, which is not suitable for drinking purpose and the parameters, are not within the permissible limits for drinking purpose. Hence, the Vellore town sewage and ground waters from such localities should be avoided totally for drinking and cooking purposes. Improving the sanitary and drainage system and adopting safe domestic and industrial waste disposal system can be control the degradation of quality of the river and ground water.

Key words: Vellore · Drinking water · Sewage water · Physico-chemical variables · Nutrients · Metal pollution

INTRODUCTION

Most developing countries have been blessed with large quantities of water but it is not available in sufficient quantities for human consumption as well as for industrial and agricultural development because of pollution of the water sources. Pollution of environment is one of the most crucial ecological crises. Different activities of man have created adverse effects on all living organisms [1]. Today the environment has become foul, contaminated, undesirable and therefore harmful for the health of the living organisms including the man [2]. Water is needed for the maintenance of life, irrigation, industries, hydroelectric power and disposal of sewage etc. Availability of water of proper quality is going to be a major problem in the coming years [3]. Every community produces liquid and solid wastes. The water supplied to the community forms the liquid wastes after it gets fouled when put to variety of uses. If untreated waste water is allowed to accumulate, it can cause unhygienic living conditions, due to the decomposition of organic matter.

Waste water is the flow of used water from a community. The characteristics of the waste water discharges will vary from location to location depending upon the population and industrial sector served, land uses, ground water levels and degree of separation between storm water and sanitary wastes [4]. Based on the domestic and industrial wastes, the municipal wastewater refers to the contents of seawater systems. It can be made up of both sanitary sewage and storm water and can comes from homes, commercial premises, schools, colleges, hospitals, manufacturing, industrial factories, etc. Domestic waste water include (i) Human and animal excreta (ii) Food residues, cleaning agents and detergents (iii) Dead bodies, household garbage etc. In general, the volume of sanitary wastewater generated is about 400 liters per capita. However, the range of flow usually varies from a minimum of about 20% to a maximum of about 400% of the average dry weather flow for small communities and about 200% for larger communities [5].

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Waste is dumped every day into rivers, lakes and streams [6]. They are estimated 2,878 cubic miles of polluted river worldwide. In developing countries, the organic load of river systems is a major problem [7]. In India, the contribution of local bodies, eg. Nagar Mahapalika, Nagar Palika, Town area, etc. through sewage is about 90%, while 3% is contributed by small-scale and 7% by medium and large-scale industries [8]. However, considering the social responsibility and other indirect advantages of pollution control, it is essential to have pollution control for sewage. Even in developed countries, pollution control measures are slower in case of domestic effluent that of trade effluent. For example, Kanpur people have generated 1800 cubic meters, i.e. approximately 900 tones of refuse and 1700 cubic meters of night soil, every day. Only about 25% of the refuse is transported by the municipality and removed, the remaining 75% is carried away in open drains, creating a great health hazard [9].

Present investigation in therefore focused on the ecological events of the sewage outlet of the Vellore Palar river area to collect information on the state of the art by recording the monthly variations in hydrography and heavy metals distribution in sewage water with a view to select the particular or specific pollutants for long term or short term monitoring the domestic waste water quality. Moreover, the different types of pollutants, which are increasing in recent times along the in and around Vellore areas. Investigation was carried out for a total period of 3 months from February 2006 to April 2006 at Sathuvachari (station 1; Ganapathi Nagar) Vellore Town (station 2) and Palar River (station 3; inlets).

MATERIALS AND METHODS

Description of the Study Areas: The study areas selected for study *viz.*, Sathuvachari (Ganapathy Nagar), Sathuvachari and waste water inlet in River Palar (Lat.12.10"N; Long.79.25'E) (Fig. 1). Sathuvachari located 2 km east of Vellore. It was a newly developing area in Vellore city. At Sathuvachari, the Aavin diary branch and integrated district courts are situated. The Ganapathy Nagar was situated in Sathuvachari near Palar River. It was newly established colony and also received total domestic and small industrial wastes of Sathuvachari. With regards to station 2, Vellore has the total population of about 1, 77,413 [10]. There are four stations of water supply (Ponnai River, Palar River, Karampattur and Otteri) per day 124 MLT water was supplied to Vellore city from the 4 stations, once in 3 days. The average water used by

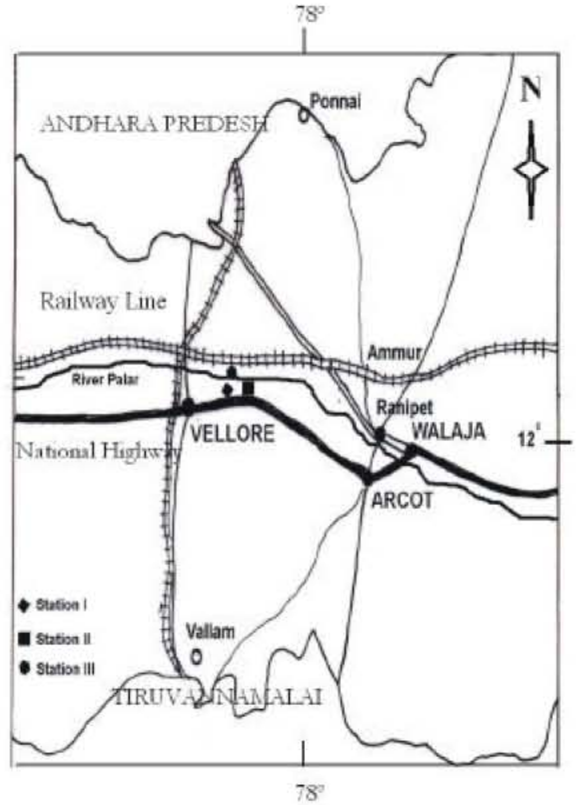

Fig. 1: Map Showing the Study Areas.

a person in 1 day is 74 liter. About 60% of supply of the water was delivered outside as waste water. The waste water stream was originated from Mandi Street and Babu Rao Street and goes around the Vellore city and at CMC hospital joined in National Theater near Vellore Collectorate it gets route into the Sathuvachari. The sample was collected near Palar River. The inlet of the waste waters in the river Palar from Vellore and Sathuvachari.

Surface water samples were collected at both the stations. Temperatures (air and surface water) were measured in the field using a standard centigrade thermometer. Turbidity was measured with the help of a Sacchi's disc; and the light extinction co- efficient was calculated using [11] formula. pH was measured using a Elico pH meter and dissolved oxygen was estimated using the methods given by APHA [12]. For the analyses of dissolved nutrients, water samples were collected in clean polypropylene container of two-litre capacity and immediately kept in ice box and transported to the laboratory to avoid contaminations, the water samples were then filtered through a Millipore filtering unit using Millipore filter paper (mesh 0.05 µm). The filtered samples were deep-frozen and the nutrients were analyses in the next day. Analysis of PO_4 -P, NO_3 -N, NO_2 -N, NH_3 -N, SO_4 -S, Cl -C and Fl -F was carried out. Total dissolved solids, Electrical conductivity Total hardness, Calcium, Magnesium, Sodium and potassium and Iron were estimated by the following the methods described by APHA [12].

RESULTS AND DISCUSSION

Physical Parameter: To study the hydrological features of municipal waste water, samples were collected from various sampling locations and the results obtained were predicted in the respective tables. Temperature, a catalyst, a depressant, an activator, a restrictor, a stimulator, a controller, a killer is one of the most influential water quality characteristics of life in water. During the study period, the atmospheric temperature varied from 31°C to 37°C. The minimum temperature was recorded as 31°C in both stations 1 and 3 in February 2006 and the maximum temperature was recorded as 37°C in station 3 at April 2006. Surface water temperature ranged from 29°C to 33°C. The minimum temperature recorded as 29°C at station 1 and 3 in February 2006. The maximum temperature recorded as 33°C at both station 2 and 3 in both March and at Station 3 in April 2006 (Table 1). Atmospheric, surface water and sediment temperature are the important environmental factors. During April, solar radiation and clear sky enhanced the atmospheric temperature whereas; in February 2006 rainfall and cloudy sky light down the atmospheric temperature and consequently the water and sediment temperature to the minimum [13].

Sediment temperature ranged from 28°C to 32°C. The minimum temperature recorded as 28°C in February 2006 at both the stations 1 and 2. Maximum temperature (32°C) was recorded in April 2006 at both the stations 1 and 3. Increased temperature, accelerate biodegradation of organic matter in the bottom deposits and the overlying water. The sediment temperature is no way influenced by municipal sewage of Uttrakashi Township, the characteristics of which have been already defined [14]. Total dissolved solids (TDS) ranged from 4088mgl^{-1} to 6874mgl^{-1}. The minimum was recorded as (4088 mgl^{-1}) in February 2006 at station 1. The maximum was recorded as 6874mgl^{-1} in March 2006 at station 2 (Table 1). Dissolved solids in the form of ions such as sodium, potassium, calcium, manganese, ammonia, chlorides, nitrites, sulphates and phosphates are main inorganic constituents of sewage and other waste water [3, 15]. Further, it's confirmed that the results are two times or three times greater than the general tolerance limits of

Table 1: Monthly variations in environmental variables (mgl^{-1}) at stations 1, 2 and 3 during the study period from February to April 2006

		February			March			April		
Sl.No	Parameters	St-1	St-2	St- 3	St-1	St- 2	St-3	St-1	St-2	St- 3
1	Air temperature (°C)	31	35	31	33	34	35	33	34	37
2	Water temperature (°C)	29	30	29	32	33	33	32	32	33
3	Sediment temperature °C)	28	28	30	30	32	30	32	29	32
4	Total Dissolved Solids	6718	4088	4872	6860	5810	6874	6202	5152	6251
5	Electrical conductivity (mic mho^{-1}cm^{-1})	9598	5840	6960	9800	8300	9820	8860	7360	8930
6	PH	7.11	7.92	7.14	7.22	7.29	7.31	7.21	7.70	7.14
7	Alkalinity	716	812	956	748	1194	892	573	557	561
8	Total Hardness	2372	724	1910	2492	2532	2894	2714	1729	2412
9	Calcium (Ca)	594	176	450	644	676	836	724	426	683
10	Magnesium (Mg)	212	68	188	212	202	192	217	159	169
11	Sodium (Na)	1000	1040	620	796	512	640	590	740	780
12	Potassium (K)	90	124	44	64	60	44	40	54	82
13	Iron (Fe)	0.02	2.96	5.38	0.56	3.08	0.76	0.10	0.18	0.13
14	Free Ammonia (NH_3)	13.68	13.32	13.34	13.88	9.62	13.42	1.16	0.24	0.41
15	Nitrate (NO_3)	1.24	1.40	1.14	1.26	1.22	1.04	0.05	0.03	0.06
16	Nitrite (NO_2)	142	32	450	250	246	468	324	192	344
17	Phosphate (PO_4)	8.74	10.04	7.64	8.78	10.1	7.88	0.19	0.14	0.14
17	Chloride (Cl)	2258	1504	1118	2594	1960	2436	1881	1683	2030
18	Fluoride (F)	1.6	1.2	0.4	0.8	0.8	0.8	0.4	0.8	0.4
19	Sulphate (SO_4)	604	98	328	480	482	638	561	413	520

Table 2: Monthly and mean concentration of heavy metals in sewage water (µgl^{-1}) at stations 1,2 and 3 during the study periods from February to April 2006

Metals	February	March	April	Mean
Sathuvachari (Station 1)				
Cu	34.50	32.00	22.40	29.6
Zn	89.00	59.00	44.50	64.16
Mn	125.00	15.00	25.60	52.2
Cr	0.340	0.240	0.143	0.24
Pb	3.90	2.50	1.00	2.4
Cd	9.00	6.00	3.00	6.0
Vellore Town (Station 2)				
Cu	30.00	20.00	30.50	26.8
Zn	96.50	66.50	76.40	79.8
Mn	112.00	92.00	82.00	95.3
Cr	0.55	0.356	0.45	0.45
Pb	3.50	4.50	0.50	2.8
Cd	0.50	3.50	ND	1.3
Palar River (Station 3)				
Cu	56.90	58.90	48.60	54.8
Zn	340.00	405.00	305.00	350.00
Mn	235.00	310.70	215.00	253.9
Cr	0.235	0.690	0.450	0.76
Pb	6.00	6.90	5.00	5.9
Cd	13.00	2.00	2.50	5.8

2100 mgl^{-1} [16]. Electrical conductivity is a useful tool to evaluate the purity of water. During the study period, electrical conductivity was found to least in February 2006 (5840 µmhos cm^{-1}) at station 2 and highest in March 2006 (9820 µmhos cm^{-1}) at station 3 (Table 1). Electrical conductivity was implying the impact of ionic composition of civic discharges in generally more. The samples are collected in the evening time the dilution is very low. So the ionic concentration was very high in the station 3.

Chemical Parameters: Hydrogen ion concentration was found narrow range and alkaline during the study period ranged from 7.11 to 7.92 (Table 1). High pH 7.92 was recorded in February 2006 at station 1. This was due to the addition of more amounts of the household wastes like detergents etc. Central Pollution Control Board [16] reported that the pH value 5.5 to 9.2 was the tolerance limits for the sewages. Alkalinity is an important test parameter in a number of industrial waste uses, notably in boiler water treatment. Present investigation, alkalinity ranged from 557 to 1194 mgl^{-1}. Minimum was recorded at Station 2 (557 mgl^{-1}) in April 2006. The maximum was recorded as 1194 mgl^{-1} in March 2006 at station 2. During the study period, the total hardness was observed ranged from 724 to 2894 mgl^{-1} at all the stations. Minimum was recorded (724 mgl^{-1}) in February 2006 at station 2. The maximum was recorded 2894 mgl^{-1} in March 2006 at station 3. Hardness is measure of polyvalent cat ions in water. Hardness generally represents the concentration of calcium and magnesium ions, because these are the most common polyvalent cat ions. Hardness caused by the heat exchanged equipments, boilers and pipelines.

Calcium and Magnesium are observed during the study period, ranged from 176 to 836 mgl^{-1}. The minimum calcium was observed (176 mgl^{-1}) in February 2006 at station 2. The maximum (836 mgl^{-1}) was recorded in March 2006 at station 3. Magnesium was recorded ranged from 68 to 217mgl^{-1}. Calcium and magnesium contributes to the hardness of water as their carbonate magnesium is always considerably lower than of calcium component excessive concentration of magnesium is undesirable in domestic water because of the problems of scale formation of pitting [12]. Sodium concentration ranged from 512 to 1040 mgl^{-1} during the study period. Minimum was recorded in March 2006 at station 2 and the maximum (1040 mgl^{-1}) was also recorded in February 2006 at station 2. A domestic discharge contributes to increase in sodium content through leaching [17]. Potassium concentration varied from 44 -124 mgl^{-1} at all the stations. Minimum (44 mgl^{-1}) was recorded at station 3 in February and March 2006. The minimum concentration was recorded is due to the waste water get way via, the agriculture field in station 3. The potassium is an essential element for plant growth and the plants took that potassium.

Iron is the most abundant in nature and it constituents about 50% of the earth's crust. During the study period the iron was ranged from 0.02 - 5.38 mgl^{-1}. The maximum (5.38 mgl^{-1}) and minimum (0.02 mgl^{-1}) were recorded in February 2006 at station 3 and 1 respectively. This may be due to the in building of new houses and metal working in small industries [18] reported that the average iron in sewage was 8.75mgl^{-1} due to the small-scale industries. Ammonia was observed during the study period ranged from 0.24 - 13.88 mgl^{-1}. Maximum (13.88 mgl^{-1}) was in March 2006 at station 1 (1). The ammonia was high at station 1 was due to the addition of fecal matters of animals as well as human beings are directly added to the waste water stream. Pandey and Carney [5] reported that typical domestic waste water contains ammonia in the concentration of 15 - 30 mgl^{-1}.

High concentration of nitrite (1.40 mgl^{-1}) was observed in February 2006 at station 2 and minimum (0.03 mgl^{-1}) observed in April 2006 at station 2 (Tab. I). This was due to the addition of nitrogenous nutrients mainly terrestrial runoff like break down of vegetation, use of chemical fertilizers in agriculture and oxidation of ammonia from of nitrogen to nitrite [19]. Nitrate concentration was high in March 2006 (468 mgl^{-1}) at station 3 and low concentration in February 2006 (32 mgl^{-1}) at station 2. High concentration may be due to the influenced oxidation of the nitrogenous ammonia of nitrite to nitrate.

Chloride was the important inorganic compound of the water. Low amount of chloride (1118 mgl^{-1}) was observed in February 2006 at station 1. The high concentration of chloride noted at Station – I, may be due to the usage of washing agents like detergents, soaps etc. and water filtering units and also chloride content was high in the waste water than other one [20]. This is also indicative of organic pollution of animal and human origin. Fluoride is critical factor, which determines the water quality, which is used for drinking, or not. Fluoride concentration was observed minimum (0.4 mgl^{-1}) in April 2006 at both station 1 and 3 and in February 2006 at station 3. The maximum (1.6 mgl^{-1}) was in February 2006 at station 1. Sulphate concentration was recorded ranged from 98 - 638 mgl^{-1}. The maximum (638 mgl^{-1}) recorded at station 3 in March 2006(Table 1). It is an important inorganic compound of waste water generated by the domestic, commercial and industrial wastes. Moreover, reported that the presence of high concentration of sulphate attributed the littering of organic wastes [21].

Phosphate concentrations ranged from 0.14 - 10.10 mgl^{-1} during the study period. Minimum (0.14 mgl^{-1}) was recorded in April 2006 at both station 2 and 3 and the maximum value (10.10 mgl^{-1}) were recorded in March 2006 at station 2. This may be due to the usage of washing powder and detergents.

Heavy Metals: Concentration of heavy metals such as copper, zinc, nickel, cobalt and cadmium occur in waste water in different forms and in different concentrations. Heavy metals can enter a water supply by industrial and consumer wastes or even from acidic rain, breaking down of soils and releasing heavy metals into streams, lakes, rivers and ground water [18]. Heavy metals such as copper, Zinc, Cadmium, Chromium, Manganese and Lead occur in the waste water in different forms at different concentrations. The monthly mean concentration of chromium were high at station 3 (0.76 μgl^{-1}) and low at station 1 (0.24 μgl^{-1}) (Table 2). The chromium present in the waste water due the ceramics, paints, pigments, photography and wood polishes are delivered in waste water channels. The present data recorded is under limits of 2.0mgl^{-1} [22].

Monthly mean concentration of Cadmium was high (6.0 μgl^{-1}) and low concentration (1.3 μgl^{-1}) at stations I and II respectively. This may be due the dumping of batteries. That was due to the accumulation of waste water from the PVC production, plastic industries. Mean concentration of copper was high (54.8μgl^{-1}) at station 3 and low concentration (26.8 μgl^{-1}) at station 2 were recorded (Tab. II). This may be due to the dyes and ceramics causes the high copper concentration in waste water and also to dumping of electrical wire waste and constructing tubes in this area [23].

Lead concentration was high (5.9μgl^{-1}) and low (2.4μgl^{-1}) at stations 3 and 1 respectively. Cadmium concentration high at station 3 was due to the waste water dumped by paints, batteries, petrol additives, pigment and compounds, cable sheath. Misra and Shukla [18] reported that the concentration of lead in sewage (6.50 μgl^{-1}) was due to the petrol additives and paints. In addition, the manganese concentration was high (253.9μgl^{-1}) at station 3 and low (52.2μgl^{-1}) was recorded at station 1 (Table 2). This was due to the old electric coils; batteries are put into the stream and also agrochemical industrial wastes [23].

Monthly mean of Zinc concentration recorded at three stations, where as the high level (350μgl^{-1}) was recorded at station 3 and low level (64.1 μgl^{-1}) at stations 1 (Table 2). Coating on iron, steel and brass alloys, pesticides containing zinc etc., are ultimately added to the sewage and municipal wastes. Higher concentrations were noted at all the stations due to the waste oils trash from automobiles, batteries, construction materials, paints and pigments [24].

Concentration of heavy metals in waste water, spatially as Zn, Mn and Cu concentrations were high at all the stations and of Mn concentration was high at station 2. Zn and Cu concentrations were high at stations 1 and 3. In general, the orders of abundance of these metals are as follows:

Station 1 - Zn>Mn>Cu>Cd>Pb>Cr
Station 2 - Mn>Zn>Cu>Pb>Cd>Cr
Station 3 - Zn>Mn>Cu>Pb>Cd>Cr.

CONCLUSION

In the present investigation on domestic and industrial wastes and its associated wastes, the values of water quality parameters revealed that majority of the sewage water quality parameters lit exceed the permissible limits [3, 16]. Chloride, fluoride, nitrite, nitrate, sulphate and heavy metals (copper, manganese, zinc, lead, cadmium, chromium) values were high at all the stations, especially station 3 (Palar inlet) which indicate the presence of non-biodegradable oxygen demanding pollution in these areas. Further, it is to be noted that the sewage water quality status in the commercial and industrial area were not clean during the study period 2006. Subsequently the same had been deteriorated perhaps due to population exploitation, industrialisation and disadvantages of preplanned setup of sewage treatment plant etc. Hence, the Vellore Municipality towards environmental protection and drinking water quality in the city should take the serious initiative.

ACKNOWLEDGEMENTS

We thank the Thiruvalluvar, Alagappa Universities and the University authorities for facilities and encouragement. We also thank Prof. L. Kannan for his encouragement and valuable support for preparing the manuscripts.

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