

Assessment of Heavy Metal Contamination in Pallikaranai Marsh - An Urban Wetland Chennai Prime Suburbs, Tamilnadu

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ABSTRACT

Wetlands play an important role in improving the water quality by filtering sediments and nutrients from surface water. The availability and quality of water always have played an important role in determining quality of life. Water quality is closely linked to water use and to the state of economic development. Chennai is among the worst affected in water quality because of its ever-expanding urban population demands for more freshwater. Due to population growth and rising income have resulted in a rapid growth in municipal solid waste (MSW) generation rate of the city. Waste generation per day has been doubled during the last decade. The present study is the area in and around Perungudi dump yard in the Pallikaranai Marsh, south of Chennai is in operation since 1986 and has increased tremendously between year 1990 to 2010. The dump yard is low lying area, closes to the sea level, poorly drained and consists of an extensive area of marshy land permanently wet and seasonally inundated. The current dumping rate is about 2,000 tons /day. The present work is undertaken to study the seasonal variation of groundwater around the Perungudi dump yard by analyzing the physico chemical characteristics, and heavy metals. The toxic heavy metals entering the ecosystem may lead to geo-accumulation, bio accumulation and bio-magnification. Heavy metals like Fe, Cu, Zn, Ni, Cr, Pb, Cd and other trace elements are important for proper functioning of biological systems and their deficiency or excess could lead to a number of disorders. The extent of contamination of groundwater quality due to landfill waste depends upon a number of factors like leachate composition, rainfall, depth and distance of the well from the pollution source. The contaminant concentrations tend to decrease during the post monsoon seasons and increase during the pre-monsoon seasons in most of the samples due to dilution effect. However, in the unprotected landfill sites, due to migration of contaminants from landfill site, post monsoon values might be higher than the pre monsoon values. Some of the samples near the land fill sites shows higher in the post monsoon than pre monsoon. This is due to the migration effect of the contaminant. The heavy metal concentration in the Marsh showed significant variations from one sampling point to other. The maximum concentrations of heavy metals were found near the Perungudi Dump yard. Garbage dumping and burning in the middle and along the roads causes severe pollution (Jayaprakash, 2010). Elevated trace metal concentrations may lead to toxic effects or bio-magnification in the aquatic environment. There should be ban in discharging sewage or industrial effluents into the Pallikaranai Marsh. The dump yard in Perungudi should be closed and dumping of municipal solid wastes should be in the outskirts away from the human habitant. Stringent management actions should be taken in order to protect the ecological stability of the wetland.

Keywords: Wetland, municipal solid waste, dump yard, groundwater, water quality, heavy metals, pre monsoon, post monsoon

1. INTRODUCTION

Wetlands with a share of 0.0001 %, among the global water sources, include swamps, marshes, bogs and similar areas and are an important and vital component of the ecosystem (IUCN, 1990) (6). Wetlands play an important role in improving the water quality by filtering sediments and nutrients from surface water. Aquatic vegetation helps in removing 90% of the dissolved nutrients like nitrogen and phosphorus and also in adsorption of heavy metals (Nixon and Lee, 1986) (4). The major cities of India are under the pressure of water scarcity. Chennai is among the worst affected because of its ever-expanding urban population demands for more freshwater. The availability and quality of water always have played an important role in determining quality of life. Water quality is closely linked to water use and to the state of economic development. Freshwater habitats occupy a relatively small portion of the earth's surface when compared to marine and terrestrial habitats. Most of the pollutants mixed with water have led to a steady decline in aquatic life. Physical and chemical characteristics of water bodies affect the abundance, species composition, stability, productivity and physiological condition of aquatic organisms. The physico

chemical parameters of an aquatic body not only reflect the type and diversity of aquatic biota but also the water quality (Hooper et al, 2005) (5).

Due to population growth and rising income have resulted in a rapid growth in municipal solid waste (MSW) generation rate of the city. Waste generation per day has been doubled during the last decade. MSW generated in Chennai includes 68 % of residential waste, 16 % commercial waste, 14 % institutional waste and 2 % industrial waste (Essaku et al 2007) (4). The physico chemical properties of the MSW generated in Chennai, showed that the majority of the waste is composed of green waste (32.3%) and inert materials (34.7%) viz., stones and glass. The area under Perungudi dump yard in the Pallikaranai Marsh, south of Chennai is in operation since 1986 and has increased tremendously between year 1990 to 2010. The dump yard is low lying area, closes to the sea level, poorly drained and consists of an extensive area of marshy land permanently wet and seasonally inundated. The current dumping rate is about 2,000 tons /day. The total area of this site is about 800 acres of which about 400 acres have been used so far for dumping. The dump yard lies at 12°57'13.5" North and 80°14'5.8" East.

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(Karthikeyan et al 2011) (9). This dump yard does not have proper lining to prevent leachate migration into underlying and surrounding groundwater environment. There is no importance given for measurement of potential impacts of leachate generation from dump yard on groundwater quality. Hence, the present work is undertaken to study the seasonal variation of groundwater around the Perungudi dump yard by analyzing the physico chemical characteristics, and heavy metals.

The toxic heavy metals entering the ecosystem may lead to geo-accumulation, bio accumulation and bio-magnification. Heavy metals like Fe, Cu, Zn, Ni, Cr, Pb, Cd and other trace elements are important for proper functioning of biological systems and their deficiency or excess could lead to a number of disorders. Food chain contamination by heavy metals has potential accumulation in bio-systems through contaminated water, soil and air. Most of our water resources are gradually becoming polluted due to the addition of foreign materials from the surroundings (Lokeswari and Chandrappa, 2006) (10).

2. STUDY AREA AND METHODOLOGY

The Pallikaranai dump yard is located south of Velachery, lies between the old Mahabalipuram road in the east, Velachery-Tambaram road on the west, Sittalappakkam on the south and Alandur on the north. It is a large topographic depression termed as the

Pallikaranai depression, stretching approximately 10 km from north to south and is about to 3 km wide from west to east. The area is low lying marshy land and is connected to the sea via the Buckingham canal and the Kovalam Estuary at the southern end of the depression. The dump yard lies between 2 and 3 km west of the Buckingham Canal and is at 3.5 to 4.5 km west of the Bay of Bengal coastline. The locations were chosen for this study which is within 2 km from the Perungudi dump yard. The locations were identified using the Global Positioning System (GPS), the latitude and longitude values were recorded. Table 1 and Figure 1). The groundwater occurs under unconfined condition in alluvium and shallow weathered aquifer and under unconfined to confined condition in deeper fracture aquifer. In general the alluvial aquifers are developed through dug well and shallow tube well. While the dug and bore wells are used for ground water development in the crystalline area. (CGWB, Report, 2010) (2). Ground water samples were collected in two seasons of pre monsoon and post monsoon for a period of two years (June 2008 to January 2010) from 13 dug wells, 9 tube wells, and 4 surface water samples from Pallikaranai Marsh and Okkiyam Madugu were collected surrounding the dumping yard. Location of the wells are given in (Table 1).

Table 1: Locations of the Wells in the Study Area

Location	Latitude	Longitude	Well type
Pallikaranai Panchayat	12.9314	80.1978	dugwell
Pallikaranai-New colony	12.9336	80.2069	dugwell
Pallikaranai-Indira nagar	12.9317	80.2092	dugwell
Perungudi-Elumalai-house	12.9556	80.2403	dugwell
Perungudi-Thirumalainagar	12.9514	80.2272	dugwell
Thuraipakkam	12.9514	80.2283	dugwell
Thuraipakkam-shanmugam-house	12.9497	80.2267	dugwell
Thuraipakkam-Adiparasakthi k.m	12.9619	80.2286	dugwell
Thuraipakkam-Jayabalan-house	12.9500	80.2267	dugwell
Thuraipakkam-Balamurugan garden	12.9397	80.2242	dugwell
Thuraipakkam-PTC quarters	12.9586	80.2439	dugwell
Mettukuppam-Pillaiyar koil street	12.9372	80.2217	dugwell
Opp-balaji dental college	12.9411	80.2006	dugwell
Pallikaranai-lake	12.9297	80.2050	surface water
Perungudi-lake(100ft road)	12.9511	80.2278	surface water
Thuraipakkam-near-LF	12.9500	80.2267	surface water
Okkiyam madhagu	12.9228	80.2325	surface water
Perungudi-Ramappa nagar	12.9592	80.2272	tube well
Perungudi-Premvilla apts	12.9522	80.2263	tube well
Perungudi-Thirumalainagar	12.9514	80.2272	tube well
Perungudi-Elumalai-house	12.9556	80.2403	tube well
Thuraipakkam-shanmugam-house	12.9497	80.2267	tube well
Thuraipakkam-Adiparasakthi k.m	12.9619	80.2286	tube well
Thuraipakkam-Deenan house	12.9500	80.2267	tube well
Thuraipakkam-Jayabalan-house	12.9500	80.2267	tube well
Mettukuppam-Pillaiyar koil street	12.9372	80.2217	tube well

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The samples were analyzed for relevant physico chemical parameters such as pH, total dissolved solids, electrical conductivity, total hardness, calcium, magnesium, sodium, potassium, BOD, COD, carbonate, bicarbonate, chloride, fluoride, nitrate, sulphate and heavy metals like iron, copper, cadmium, zinc, manganese, chromium, nickel and lead. pH & EC was measured in the field immediately after collection of water samples. All the parameters were analyzed following the procedure specified in APHA (1998) (1). For heavy metal analysis, separate samples were collected after collection of the water sample, the samples were acidified immediately with 1:1 Hydrochloric acid. Similarly, separate samples were collected for BOD and COD analysis. The samples were immediately transported to the laboratory and carefully stored for analysis in the TWAD Board, Chennai. pH, EC, sodium, potassium, nitrate, sulphate, chloride and fluoride were analyzed in the instrumental method. Total hardness, calcium, magnesium, carbonate and bicarbonate were analyzed in titrimetric method. All the heavy metals analyzed in atomic absorption spectro photometric method. All the samples were analyzed in Water Analysis Laboratory in TWAD (Tamil Nadu Water Supply and drainage Board), Chennai.

3. RESULTS AND DISCUSSION

The toxic heavy metals entering the ecosystem may lead to geo-accumulation, bio accumulation and bio-magnification. Heavy metals like Fe, Cu, Zn, Ni, Cr, Pb, Cd and other trace elements are important for proper functioning of biological systems and their deficiency or

excess could lead to a number of disorders. Food chain contamination by heavy metals has potential accumulation in bio-systems through contaminated water, soil and air. Most of our water resources are gradually becoming polluted due to the addition of foreign materials from the surroundings (Lokeswari and Chandrappa, 2006) (10).

The analytical results reveal that the average copper content was 0.06mg/l which exceeded the desirable of CPHEEO (1999) (3) (0.05mg/l) in the pre monsoon periods and the values are high in the well locations which are closer to the dump yard (Table 2.1, Figure 2.1). Large amount of copper content in water may result in liver damage, cause CNS irritation and depression. In water supply system, it enhances corrosion of aluminum particular (CGWB report, 2004) (2).

The average Iron content was 0.35 mg/l in the dug wells, tube wells and surface water in both pre and post monsoon periods which exceeds CPHEEO (1999) (3), desirable value of 0.10 mg/l. The Iron content was higher in the post monsoon season (Table 2.2, Figure 2.2). High content of Iron has adverse effect on domestic uses and water supply structures (IS 10500, BIS,2003) (7).

In case of Zinc, the average value was 0.05mg/l in the dug wells, tube wells and surface water in both pre and post monsoon periods and was below the desirable limit of CPHEEO (1999) (3), (5.00 mg/l) (Table 2.3, Figure 2.3). Zinc is an essential element in human metabolism. Taste threshold for zinc occurs at about 5 mg/l, imparts astringent taste to water (CGWB Report, 2004) (2).

Table 2.1		
Average Copper content during pre-monsoon and post monsoon period		
Well Type	Pre monsoon	Post monsoon
Dug Well	0.0031	0.02
Tube Well	0.02	0.02
Surface Water	0.005	0.01
Desirable limit for copper : 0.05 mg/l (CPHEEO, 1999)		
Table 2.2		
Average Iron content during pre-monsoon and post monsoon period		
Well Type	Pre monsoon	Post monsoon
Dug Well	0.14	0.3
Tube Well	0.16	0.25
Surface Water	0.32	0.56
Desirable limit for iron : 0.1 mg/l (CPHEEO, 1999)		
Table 2.3		
Average Zinc content during pre-monsoon and post monsoon period		
Well Type	Pre monsoon	Post monsoon
Dug Well	0.18	0.06
Tube Well	0.22	0.08
Surface Water	0.01	0.04
Desirable limit for zinc : 5 mg/l (CPHEEO, 1999)		
Table 2.4		
Average Lead content during pre-monsoon and post monsoon period		
Well Type	Pre monsoon	Post monsoon
Dug Well	0.05	0.06
Tube Well	0.05	0.07
Surface Water	0.03	0.02
Desirable limit for lead : 0.05 mg/l (CPHEEO, 1999)		
Table 2.5		
Average Nickel content during pre-monsoon and post monsoon period		
Well Type	Pre monsoon	Post monsoon
Dug Well	0.03	0.03
Tube Well	0.03	0.05
Surface Water	0.02	0.04
Desirable limit for Nickel : 0.10 mg/l (IS: 10500, 1991, (BIS,2003))		
Table 2.6		
Average Manganese content during pre-monsoon and post monsoon period		
Well Type	Pre monsoon	Post monsoon
Dug Well	0.42	0.5
Tube Well	BDL*	BDL*
Surface Water	0.06	0.07
*BDL; Below detectable limit		
Desirable limit for manganese : 0.05 mg/l (CPHEEO, 1999)		
Table 2.7		
Average Chromium content during pre-monsoon and post monsoon period		
Well Type	Pre monsoon	Post monsoon
Dug Well	0.02	0.004
Tube Well	0.01	0.002
Surface Water	BDL*	BDL*
*BDL; Below detectable limit		
Desirable limit for chromium: 0.05 mg/l (CPHEEO, 1999)		
Table 2.8		
Average Cadmium content during pre-monsoon and post monsoon period		
Well Type	Pre-monsoon	Post-monsoon
Dug Well	0.01	BDL*
Tube Well	0.01	BDL*
Surface Water	BDL*	BDL*
*BDL; Below detectable limit		
Desirable limit for cadmium: 0.01 mg/l (CPHEEO, 1999)		

Figure 2.1 Average Copper content during pre monsoon and post monsoon period

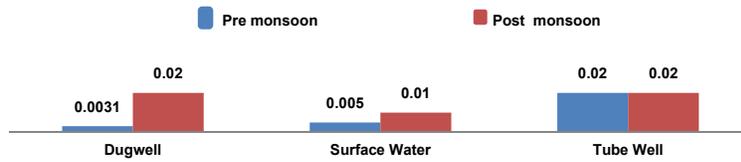


Figure 2.2 Average Iron content during pre monsoon and post monsoon period

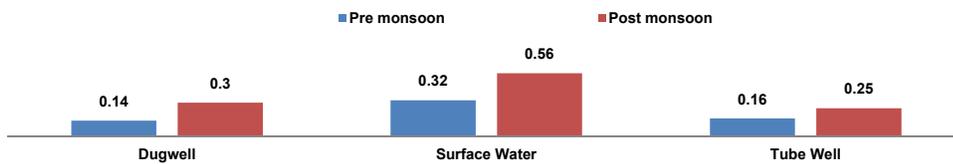


Figure 2.3 Average Zinc content during pre monsoon and post monsoon period

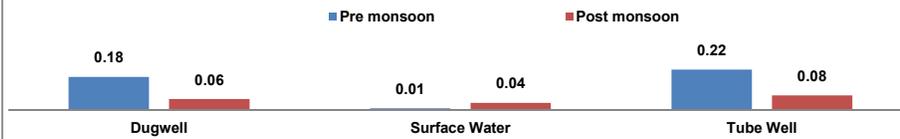


Figure 2.4 Average Lead content during pre monsoon and post monsoon period

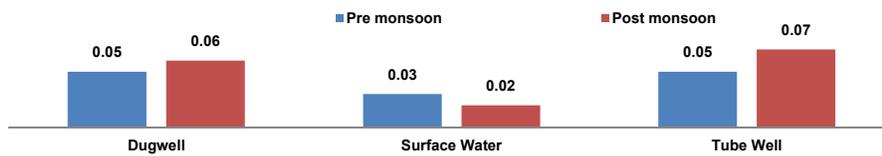


Figure 2.5 Average Nickel content during pre monsoon and post monsoon period

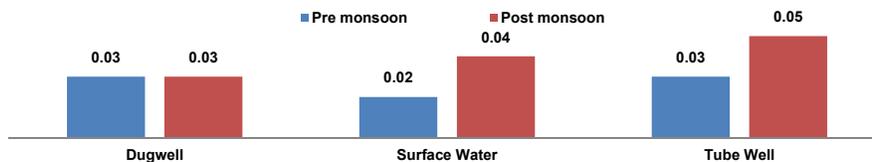
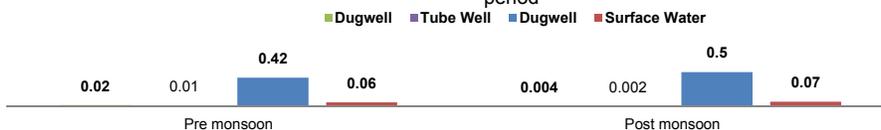


Figure 2.6 Average Manganese content during pre monsoon and post monsoon period



Figure 2.7 Average Chromium content during pre monsoon and post monsoon period



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The average Lead content was 0.06mg/l in the dug wells, tube wells and surface water in both pre and post monsoon periods and was above the desirable limit of CPHEEO (1999)(3), (0.05 mg/l) (Table 2.4, Figure 2.4). Toxic in acute and chronic exposures of lead content in water, burning in mouth, severe inflammation of gastro-intestinal tract with vomiting and diarrhea, chronic toxicity produces nausea, severe abdominal pain, paralysis, mental confusion, visual disturbances, anemia etc. (CGWB Report, 2004) (2).

Similarly, the average Nickel content was 0.30mg/l in the dug wells, tube wells and surface water in both pre and post monsoon periods which exceed the Drinking Water (IS: 10500, 1991) (7) value of 0.10mg/l. The average Nickel content was higher in the post monsoon season (Table 2.5, Figure 2.5). This is due to the solubility and mobility of species within the landfill and also influence of the pH value. High levels of nickel content may be carcinogenic (cancerous), can react with DNA resulting in DNA damage (CGWB Report, 2004) (2).

The average Manganese content was 0.32 mg/l in the dug wells, tube wells and surface water in both pre and post monsoon periods which exceeds the desirable limits of CPHEEO, (1999) (3) with a value of 0.05mg/l (Table 2.6, Figure 2.6). Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply structures (IS 10500, BIS, 2003) (7).

The high values of Chromium content in water was seen in few water samples which are closer to the dump yard in the locations of Perungudi-Thirumalainagar, Perungudi-Elumalai-house Thuraipakkam-Jayabalan and Thuraipakkam-Balamurugan garden with an average value of 0.02mg/l and is within the desirable value of CPHEEO, (1999) (3) (0.05mg/l) (Table 2.7, Figure 2.7). Hexavalent state of chromium produces lung tumors, can produce coetaneous and nasal mucous membrane ulcers and dermatitis (CGWB Report, 2004) (2).

The Cadmium content was seen in the water samples in four locations close to the dump yard and the average cadmium content was 0.01mg/l and was Thuraipakkam-Jayabalan both in dug wells and tube wells and Thuraipakkam-Shanmugam both in tube wells and dug wells. The desirable level for cadmium was 0.01mg/l by CPHEEO (1999) (3), and the average cadmium content in the present study is within the desirable limit (Table 2.8). Acute toxicity may be associated with renal, arterial hypertension, itai-itai disease. Cadmium salts cause cramps, nausea, vomiting and diarrhea (CGWB Report, 2004) (2).

4. CONCLUSION

The extent of contamination of groundwater quality due to landfill waste depends upon a number of factors like leachate composition, rainfall, depth and distance of the well from the pollution source. The

contaminant concentrations tend to decrease during the post monsoon seasons and increase during the pre monsoon seasons in most of the samples, due to dilution effect. However, in the unprotected landfill sites, due to migration of contaminants from landfill site, post monsoon values might be higher than the pre monsoon values. Some of the samples near the land fill sites shows higher in the post monsoon than pre monsoon. This is due to the migration effect of the contaminant. The heavy metal concentration in the Marsh showed significant variations from one sampling point to other. The maximum concentrations of heavy metals were found near the Perungudi Dump yard. Garbage dumping and burning in the middle and along the roads causes severe pollution (Jayaprakash, 2010) (8). The high value of heavy metal concentration is due to the dumping of waste from industrial, municipal and domestic activities (Prabu, 2009) (12). Elevated trace metal concentrations may lead to toxic effects or bio-magnification in the aquatic environment. There should be ban in discharging sewage or industrial effluents into the Pallikaranai Marsh. The dump yard in Perungudi should be closed and dumping of municipal solid wastes should be in the outskirts away from the human habitant. Stringent management actions should be taken in order to protect the ecological stability of the wetland.

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