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Full Length Review Article

CURRENT STATUS OF PALLIKARANAI WETLAND: A REVIEW

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ABSTRACT

Wetlands provide innumerable valuable services to the society at large such as recharging ground water, recycling nutrients, attenuating floods and as natural habitat supporting various species biodiversity. Due to rapid urbanization and industrialization the only available rain water harvesting wetland of Chennai city, the Pallikaranai marsh land which has been designated as a reserve forest area has been reduced to one-tenth of its original extent due to anthropogenic pressures. The presence of a major dumpyard and sewage treatment plant operated in the ecologically sensitive areas of Pallikaranai marsh pose a great threat to the biodiversity population of the wetland. Hence, the status of information produced in this study from published results will provide a pre-requisite baseline data on Pallikaranai marsh land and Perungudi solid waste facility.

INTRODUCTION

Lands transitional between terrestrial and aquatic ecosystems where the water table is usually near the surface or covered by shallow water (Mitsch and Gosselink, 1986) occupy 58.2 million ha in India, including areas under paddy cultivation (Venkataraman, 2003), however development in urban areas has led to the loss of more than 60% of national wetlands (Sundaresan *et al*., 2015). These wetlands are biologically diverse support systems that maintain the essential ecological processes and perform a number of valuable functions such as ground water recharge, flood control, improve water quality of the area by natural filters and sequestration by plants, provide habitat for indigenous and migratory birds and harbors variety of germplasm of rare and endangered species. Unfortunately, only 26 sites have been deputed as Ramsar sites while whereas other smaller wetlands which perform valuable functions remain ignored in the policy process as 'waste lands' (Bassi *et al*., 2014).

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Description of Study Area

The only urban wetland of Chennai city Pallikaranai marsh is a freshwater swamp located in the South of Chennai bound by Velacherry in the North, Medavakkam in the South, Kovilambakkam in the West and Okkiyum Thoraipakkam in the East with a geographical area of 80 sq.km running parallel to the Coum river and the Bay of Bengal coast on the eastern side. In Chennai wetlands and river bodies are preferred sites for dumping of solid wastes and a receiving basin for industrial and domestic effluents due to the decline of living areas and invasion of population in the city. Athough a vast portion of the marsh was declared as reserve forest in 2007 under the Tambaram forest range department (Malleshappa and Jayanthi, 2013), ironically these protected lands are being encroached for urban development.

Functions of Pallikaranai Marsh

Hydrology

Flood Control

The water table at Pallikaranai marsh is usually at or near the surface of the land, the standing water does not exceed 3 m,

during floods the excess water is discharged into Okkiyum Madavu, then the water is channeled into Cooum and is drained finally into the Bay of Bengal sea coast through Muttukkadu - Kovalam creek.

Characteristics	Pallikaranai – Marsh Wetland
Geographical Location	Lies between 80.20°N to 80.23°N and 12.92°E to 12.96°E
Area	80 sq.km
Catchment area	235 sq.km
Surface elevation	3 m-7 m
Temperature	35 - 42°C (Summer) and 25 - 34°C (Post Monsoon)
Rainfall recharge	North East Monsoon – 340mm (Nov - Jan) and South West Monsoon (Jul - Sep)
Pedology	Vertisol
Geology	Charnockite weathered rock bed
Hydrology	Runoff from Velacherry, hills and tanks on west and south west find way through channels and seasonally inundate the Pallikaranai marsh
Drainage	Excess water is drained into Okkiyum Madavu then to Cooum and reaches finally the Bay of Bengal sea coast through Muttukkadu- Kovalam creek

Patnaik and Srihari, 2003; Parameswari *et al*., 2015; Malleshappa and Jayanthi, 2013.

One of the main reasons for the 2015 floods in Chennai was the sand bar formation (accumulation of silt and waste) near the canal mouth of the estuaries, creeks and the unchecked urban development that prevents the exit of natural water run-off. After the heavy floods there was a misconception that the floods ecologically restored the water bodies naturally by flushing the effluents into the sea. When silt accumulated at the canal mouths was removed by PWD (Nurullah, 2016) rain water drained into the sea, leaving behind sludge on the Cooum riverbeds, naturally a significant decrease in the water levels in the Pallikaranai swamp was noted between December and January.

Recharge Aquifer

Wetlands provide water security to the region, they retain water during floods due to their high organic content and release it during dry periods. Less water is lost into the atmosphere due to the cover provided by the wetland vegetation. Due to the destruction of natural recharge zones in the marsh (Sunderasan *et al*., 2015), unregulated extraction of water has resulted groundwater levels of shallow aquifers in Velacherry and areas within the catchment area to fall below 2.21 to 7.64 m below ground level (CGWB, 2008).

Improves Water quality

Marshes act as natural pollution filters (Verma, 2015), they help to purify water by trapping many pollutants, suspended solids, attached nutrients and disease causing microbes. Deterioration of water quality in wetlands are an issue of concern, hence constructing effective liners at the bottom will prevent influent seepage of bad water and polluted effluents into the ground water from dumping grounds.

Haven for diverse species of flora and fauna

The wetland is covered by a mosaic of aquatic grass species (29 sp.), scrubs (18 sp.), sedges (9 sp.) and climbers (8 sp.). The wetland is rich in faunal species. It is home for 10 *sp.* of mammals, 115 *sp.* of birds, 21 *sp.* of reptiles, 10 *sp.* of amphibians, 46 *sp.* of fish, 7 *sp*. of butterflies, 5 *sp.* of Crustaceans and 9 *sp.* of Mollusk (Vencatesan, 2007).

Water Birds

Pallikaranai marsh functions as a habitat for indigenous and migratory birds (Wagh *et al*., 2015). Every year a huge number of water fowls and waders are sighted on the mud flats of the marsh land between June to December (during winter) for feeding, breeding and roosting. Due to the availability of ideal climate for breeding and food resources, it is an important stopover for the migratory species for resting and refueling. Water fowls form important links in the food web and nutrient cycles (Malik and Joshi, 2013). Nikhil Raj *et al*. 2010 recorded 101 *sp.* of birds of these 76 *sp*. are resident birds and 25 *sp.* are migratory winter birds. In 2000 a rich repository of the Black winged stilts (*Himantopus himantopus*) and Little Grebe (*Tachybaptus ruficollis)* dominated the marshland whereas in 2010 population of Black winged stilts and Cattle Egrets (*Bubulcus ibis*) dominated the area. Pallikaranai wetland also habors two threatened species of birds, the spot- billed Pelican (*Pelicanus philippensis*) and Black head Ibis (*Threskiornis melanocphalus*). Between Nov 2012 to May 2013 there has been a considerable increase in Flamingo population (Balakumar and Das, 2015). At present the number of birds visiting the site has decreased alarmingly.

Threats

Municipal solid waste facility and sewage treatment plant

The Chennai metropolis waste dumpyard and Perungudi Sewage Treatment Plant occupy 250 acres of prime marsh lands (Nikhil Raj *et al*., 2010). Perungudi dumpyard receives around 5000 tons of waste per day. Contaminated liquid in the form of leachates generated from liquids present in the refuse, intrusion of ground water into the landfill and different sources of moisture entering the uncovered waste by precipitation (Vasanthi *et al*., 2008) migrates from the dumpsite and form a plume in approximately 1.5km to 1.75km spatially and to a depth of 100m (Mathiazhagan, 2013) polluting the hydrological system of Pallikaranai marsh contaminating both surface water and ground water. Another emerging great threat to the fragile ecosystem is the Alandur MSW facility on the Eastern side of Tambaram to Velacherry road. Perungudi Sewage Treatment Plant (STP) treats around 54 million litres/ day by activated sludge process (CMW, 2011) treated effluents from STP are let off into the marsh land since 2005. Unchecked sewage drains from apartments and housing colonies are another source of pollution in the marsh.

A.

- **Encroachment**

The wetland which extended to more than 50sq.km originally about 30 years back is reduced to 5.9 sq.km in 2007 and is further reduced to 3.17 sq.km (793 acres) at present (Gazette notification GO.Ms. No. 52, Environment dated 9th April, 2007).

Government initiatives - Conservancy history

During 1985 – 1986, the Government of India identified Pallikaranai marsh as one of the 94 wetlands under the

National wetland and Conservation Programme (NWCMP) (Jayanthi *et al*., 2012). Later in 2007, the Tamil Nadu Government (Gazette notification GO. Ms. No. 52, Environment dated 9th April, 2007) declared a part of the Pallikaranai marsh (3.17 sq.km) as a reserve forest under Section 4 of the Tamil Nadu Forest Act, 1882 realizing the ecological significance of the marsh in an expanding metropolis (Vencatesan, 2007). In 2012, 115 wetlands have been listed under the National wetland conservation programme by MoEF and Pallikaranai is one among them (NWCP, 2009). The purpose of the present study is to provide a comprehensive compilation on available works conducted in and about Pallikaranai wetland.

Table 1. Review of Pallikaranai marsh from 2002 to 2015

SOURCE	SUBJECT*							LOCATION**	TEST SAMPLE
	PC	HM	WC	MB	BD	EC	GEO		
Aravindkumar *et al*., 2014	●							Around PM	Bore Well, Surface Water
Azeez *et al*., 2007						●		PM	Review
Balakumar and Das, 2015								Around PM	Questionnaire Survey
Jayakumar *et al*.,								Around PM	GIS
Jayanthi *et al*.,2012	●							Around PM	Ground Water
Jayaprakash *et al*., 2010		●					●	PM	Sediment sample
John Paul *et al*., 2010	●				●			PM	Molluscan Diversity
Karpagavalli *et al*., 2012	●	●						Around PM	Surface Water
Lavanya *et al*., 2013				●				Around PM	Surface Water
Nikhil Raj *et al*., 2010					●			PM	Faunal Diversity
Parameswari *et al*., 2015							●	Around PM	Ground Water
Patnaik *et al*., 2004					●			PM	Floral & Faunal Diversity
Pfeffier *et al*., 2008						●		PM	GPS – Land use
Rao *et al*., 2015								Around PM	Ground Water, Surface Water
Roumeau *et al*., 2015								Around PM	Ground Water
Sakthivel *et al*.,						●		PM	Review
Vaidhyanathan and Gowri, 2013								Around PM	Sanitation Quality
Vasanthi *et al*., 2008	●	●	●					Around PM & PDG	Ground Water, Leachate
Vencatesan, 2007						●		PM	GPS – Area Survey

*PC- Physico Chemical; HM - Heavy Metal; WC - Waste composition; MB - Microbiology; BD - Biodiversity; EC – Eco Conservation; GEO- Geology
** PM – Pallikaranai Marsh, PDG – Perungudi Dumping Ground

Table 2. Physico chemical properties recorded in Pallikaranai marsh

ECOLOGICAL SOURCE	pH	TDS (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)	COD (mg/L)	EC (ms/cm)	SOURCE
Bore Well	8.60 - 8.80	550 - 750	370 – 390	610 - 675	-	-	Banuraman *et al*., 2011
Dug well (PM)*	6.75 - 8.12	1535 - 6053	-	331- 1267	206 - 276	1334 - 4853	Jayanthi *et al*., 2012
Dug well (Po.M)*	6.98 - 7.64	1316 - 7859	-	225 - 1120	93 - 129	1020 - 4090	Jayanthi *et al*., 2012
Tube well (PM)*	7.08 -7.89	1164 - 6488	-	141 - 1273	82 - 269	1199 - 7254	Jayanthi *et al*., 2012
Tube well (Po.M)*	6.80 - 7.79	1148 - 4573	-	250 - 632	31- 119	1161 - 4406	Jayanthi *et al*., 2012
Surface Water	6.50 - 8.40	-	40 - 1650	-	8 - 740	590 - 42900	Karpagavalli *et al*., 2012
Surface Water (PM)*	7.23 - 7.58	645 - 4596	-	177 - 1249	20- 117	536 - 3237	Jayanthi *et al*., 2012
Surface Water (Po.M)*	7.28 - 7.54	697 - 5306	-	42- 420	25 - 129	632 - 6102	Jayanthi *et al*., 2012
Required desirable limit	6.50 - 8.50	300	-	300	20	-	BIS
Max. permissible limit	9.2	1500	-	600	20	-	BIS

***PM –** Pre Monsoon, **Po.M –** Post Monsoon

MATERIALS AND METHODS

The literature review consists of research papers from 2004 to 2015 on the Pallikaranai marsh. The research reports considered for the analysis give an understanding on the works that have been done in Pallikaranai. Table 1 review shows that only these areas of Physico-Chemical (PC); Heavy Metal (HM); Waste Composition (WC); Microbiology (MB); Biodiversity (BD); Eco-Conservation (EC) and Geology (GEO) have been so far explored in Pallikaranai. From the review process (Figure 1) we understand that the mentioned study aspects were studied below 50%. Physico chemical and Eco conservation studies covered above 20%, heavy metal (15%), Biodiversity (15%), Geology (10%) and Waste composition and Microbiology studies (5%)(Figure 1). This shows the study area needs more attention because countable research articles are only available from 2004 to 2015 online.

Physicochemical Parameters

Hydrological conditions can directly modify or change chemical and physical properties such as nutrient availability, degree of substrate anoxia, soil salinity, sediment properties and pH (Gosselink and Turner, 1978). These slight modifications of the physicochemical environment have a direct impact on species composition, richness and ecosystem biodiversity (Venkataraman, 2003). From the inferred results, it can be concluded that ground water around Pallikaranai marsh possesses high values of TDS, anions and cations which make the water non-potable and the operation of dumpsite is mostly responsible for accelerating the ground water contamination in the area (Table 2).

Heavy Metal

Heavy metals are elements within specific gravity greater than 5g/cm^3 (Nies, 1999) and occur at less than 0.1% levels in the earths crust but anthropogenic activities such as industrial processing of metals, liberation of waste containing metallic compounds add upto natural background level of the elements (Kannan, 1991). Enzyme holding detergents in domestic

effluents, sewage outfalls and biological treatment plants contain trace amounts of Fe, Mn, Cr, Co, Zn, Sr and B (Nagajyoti *et al*., 2010). Karpagavalli *et al*. (2012) revealed that Cd and Cr levels exceeded the permissible limit in surface waters around Pallikaranai marsh. This might be due to Cr and Cd having wide applications in day to day life. Cu was found the least in the water samples though Cu is used widely in electrical goods and kitchen wares, because it is less likely to be broken down and leached into soil.

Table 3. Heavy metal concentration recorded indifferent locations of Pallikaranai marsh

Ecological Source	Sediment (mg/g)	SW (mg/L)	GW[1](mg/L)	GW[2] (mg/L)	Permissible Limit (mg/L) in water
	Location				
	PM	Around PM	Around PM	Around PM	
Al	20.0 - 80.0	-	-	-	0.03
Cd	0 - 0.006	0 - 0.019	-	-	0.003
Co	2.0 - 8.0	-	-	-	-
Cr	0 - 1.5	0.10 - 1.52	-	-	0.05
Cu	0.02 - 0.32	0 - 0.02	0.01 - 0.099	0.023 - 0.088	0.05
Fe	12.0 - 57.0	0 - 1.52	0.258 - 1.024	0.251 - 1.142	0.3
Hg	0.2 - 1.4	-	-	-	0.001
Mn	0.15 - 1.05	-	-	-	0.1
Ni	0 - 0.45	0 - 0.60	-	-	0.02
Pb	0.01 - 0.19	0.03 - 1.13	0.0123 - 0.09	0.005 - 0.097	0.01
Zn	0 - 0.6	0.002 - 0.14	0.39 - 0.953	0.416 - 0.931	5
Source	Jayaprakash *et al*., 2010	Karpagavalli *et al*., 2012	Vasanthi *et al*., 2008	Vasanthi *et al*., 2008	ISO 10500: 2012

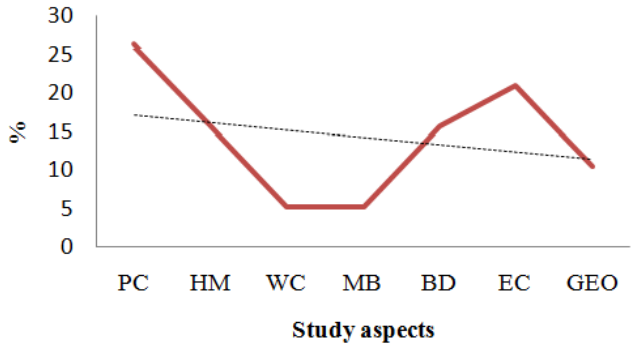
[1] wells within 1.25 km,[2]wells beyond 1.25 km
SW – Surface Water, GW – Ground Water

Table 4. Possible industrial source and its human risk of the toxic chemical elements

S.No	ELEMENT	INDUSTRIAL SOURCE	MECHANISM OF TOXICITY IN HUMANS[a,b,c]
1	Al	➢ Buildings, automobiles, ➢ Utensils, electric wires, ➢ food packaging, canning	i) Intereferes with phosphate metabolism -Dephosphorylation of proteins, e.g., complex formation with inositol phosphate. ii) Reduces bioavailability of ATP and casein
2	Cd	➢ solar cells, paint pigments, ➢ photoelectrical and electron optical devices, ➢ Ni-Cd batteries, Cd stearates used as stabilizers in production of PVC, cigarettes	i) Interference with tubular resorption of low molecular weight proteins. ii) Displacement of zinc from critical site in zinc-containingenzymes. iii) Liberation of cadmium from am etallothionein boundmetal, through digestion bylysosomes, results in toxic effects. iv) Potent enzyme inhibitor and interacts with -SH- groups of several enzymes.
3	Co	➢ Glass, ceramics, paints, ➢ varnish, resins, ➢ alloys for tooth prosthesis, as cyancobalamine in medicine	i) Myocardial toxicity is attributed to decreased oxidation of pyruvate in the heart muscle ii) Production of hypoxia inducible factor iii) Increased carotid body neural discharge
4	Cr	➢ matches, storage media for computers, ➢ chromeplating Dyes, tanning of leathers, ➢ cassettetapes, Pyrotechniques and photography	i) Allergic and corrosive nature. ii) Damage to DNA through interference with DNA-polymerase enzyme and free-radical formation. iii) Carcinogenic action. iv) Essential for insulin metabolism as Glucose Tolerance factor
5	Cu	➢ Whole metal in wires and vessels, iti sless like lyto be broken down and leached into the soil	i) Local irritation of gastric mucosa. ii) Release of hepatic copper in to the blood stream and extracellular fluids causes damage to susceptible cells including those of brain and liver.
6	Fe	➢ Biogeochemical cycle ➢ kitchen wares and utensils	i) Catalytic effect on the production of the hydroxyl radical. ii) Peroxidation of lysosomal membranes iii) Release of serotonin.
7	Hg	➢ Thermometers, barometers ➢ mercury vapour lamps, x-ray tubes, ➢ dental amalgam, chloralkali industry, ➢ electronic equipment, paints, ➢ military detonators, disinfectants, synthetic silk.	i) Affinity for thiol groups ii) Neurotoxicities of $MeHg^+$ and Hg° are distinctly different. The effects of mercury vapour on brain function are neuropsychiatric in nature, whereas those of $MeHg^+$ are largely sensorimotor. Inorganic Hg^+ is 100 times more potent than $MeHg^+$ as inhibitor of brain muscarinic receptors. iii) Impairment of primary and secondary immune response.
8	Mn	➢ Alloys including steel, dry-cell batteries, ➢ diesel exhaust filters, fertilizers, pigments, ➢ pharmaceuticals, catalysts, dyes, paint, dryers.	i) Disturbances in the brain catecholamine metabolism. ii) Inhibition of dopamine, melanin and serotonin synthesis in the basal ganglia of brain
9	Ni	➢ Alloys for corrosion resistant equipment, cooking utensils, ➢ coinage, heating elements, gas turbines, ➢ jet engines, electroplating, paints, pigments, batteries	i) Nickel carbonyl inhibits ATP-ase and RNA-polymerase activities in tissues. ii) Peroxidative degradation of membrane lipids. iii) Inhibition of natural killer-cell activity, T-cell mediated immune response and macrophage function, allergenic and carcinogenic action.
10	Pb	➢ storage batteries, antiknock agents in petroleum and gasoline, ➢ paints, glassware, ceramics, printing press	i) Altered permeability of brain capillaries, segmental demyelination and axonal degeneration of peripheral motor nerves. ii) Blood pressure and renal effects are mediated through the renin-angiotensin system. Interference with several enzymes involved in haeme synthesis and reduction in haemoprotein biosynthesis.

[a]Athar and Vohora, 1995; [b]Wood *et al*., 2012; [c]Eisler, 1986

Cu and Fe are not generally thrown in waste. Hence, heavy metals of concern such as Cd, Pb, Ni could have found its way into the ecosystem from the Muncipal solid waste facility by leaching into the soil and contaminating ground and surface waters in and around the marsh.



PC- Physico Chemical; HM - Heavy Metal; WC - Waste composition; MB - Microbiology; BD - Biodiversity; EC – Eco Conservation; GEO- Geology

Figure 1. Percentage of subjects covered in Pallikaranai marsh from 2002 to 2015

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