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Pollution due to Heavy Metals in Coimbatore Wetlands, India

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Abstract

Coimbatore is the second largest industrial city of Tamil Nadu and it is also mentioned as the Manchester of Tamil Nadu. There are plenty of wetlands available in this city and unfortunately these wetlands are now changing to waste lands because of the increasing discharge of effluents from various industries. These effluents further reduce the productivity of soil and it contaminates the natural water bodies as well as ground water. In this study the water samples were collected for heavy metals analysis by using Atomic absorption spectrophotometer. The results from the water analysis revealed that, heavy metal concentration of Cd, Cr, Cu, Ni and Pb were exceeded the permissible limit prescribed for drinking water (WHO standard) and also irrigation standard (FAO). Water samples from 12 wetlands exhibited heavy metal concentration in the following range: Cd - 0.2 to 0.7 mg L^{-1}, *Cr- 3* mg L^{-1} *to 518* mg L^{-1}, *Cu -1.0 to 98* mg L^{-1}, *Ni - 7.0 to 33* mg L^{-1} *and Pb - 0.9 and 3.0* mg L^{-1} *respectively. The results evident that the relative proportion of heavy metals are in an increasing the order of Cr> Cu > Ni >Pb> Cd. This study also delineated the heavy metal contamination in the 12 wetlands of Coimbatore city using ArcGIS 9.3. Finally we conclude that the water in the wetlands is not fit for human and animal consumption.*

Keywords: Heavy metals, pollution and wetlands.

Introduction

Pollution is one of the serious problems in many countries like India that threatens the environmental and human health[1]. Even though heavy metals (elements having densities greater than 6.0 g/cm3 and denote metals) are associated with pollution and toxicity, they also considered as essential elements. Naturally heavy metals are available in soils, waters and living organisms in a minimum quantity and they are crucial for healthy life. Once the heavy metals concentration exceeds the prescribed limit, this may cause toxicity to various living organisms including human beings. Some of these metals like Zn, Cu, Mn, Ni, and Co are micronutrients which necessitate the plant growth, while others have unknown biological function[2]. These metals can enter the soil environment from variety of sources like industrial wastes, fertilizers, vehicle emission, domestic and urban wastes[3]. Heavy metals are among the most commonly encountered pollutant in the environment and the treatment of this pollutant is also difficult. These heavy metals if not properly managed could easily dissolve in waste water and discharged into surface water. These dissolved metals can enter into food chain and cause serious health hazards[4].

Large number of metal based industries is situated in Tamil Nadu at various districts like Vellore, Erode, Dindigul and Coimbatore in an unorganized manner[5]. The major industries located in Coimbatore are textile, dyeing, electroplating, motor and pump set, foundry and metal casting industries[6]. In the Coimbatore city, effluents from most of the industries are directly discharged into soil, road canals and the rivers without any proper treatment[7]. Mapping the distribution of pollutants in soil and water is essential to delineate contamination. Remote sensing technology and integration of GIS has proved its capacity to identify the source of pollution and accurately determine its location and extent. Mapping polluted areas based on given pollution thresholds is significant since these information's are crucial in formulating environmental action strategies like, soil remediation for heavy metal pollution[8]. In this background the heavy metal pollution of wetlands in Coimbatore city was assessed and the distributions of heavy metals were delineated.

Material and Methods

Study Area: Coimbatore is located at 11.0161° N, 77.971° E and 426.72 meter above sea level and has an area of about 7,469 sq.km square kilometers in the north western Tamil Nadu, very close to Western Ghats. Coimbatore is surrounded by mountains on the west and the nilgris biosphere reserve on the northern side. The eastern side of the district, including the city is predominantly dry. The city of Coimbatore has twelve Wetlands Periyakulam, Singanallur, Valankulam, Muthanankulam, Perur-1, Perur-2, Sulur-1, Sulur-2, Kurichkulam, Narasampathi, Krishnampathi and Selvapuram.

Samplings: Water samples were collected from the 12 wetlands in one lit polypropylene containers which were rinsed with distilled water followed by sampling waters. After the pH and EC measurement, the water samples were added with toluene (1ml L^{-1}) to stabilize the original valency state of heavy metals.

Analytical Procedure: The pH and electrical conductivity (EC) of collected water samples were measured during the sample collection by using combined electrode pH meter and conductivity meter respectively. For heavy metal extraction, 10 ml of water sample was digested using 15 ml of Aqua regia (HNO_3: HCl in 1:3 ratio) and the volume was made to 100 ml. The total content of metals in the digest was measured in an Atomic Absorption Spectrophotometer (AAS, Varian Spectra AA 200, Perkin Elmer) using acetylene flame[9].

Delineation of metal contamination 'hot spots': Remote sensing technology and integration of Geographical Information System (GIS) have proved its capacity to identify the source of pollution and accurately determine its location and extent of contamination. Therefore, in the present study, the dominant heavy metals were identified, they are cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni) and lead (Pb). After the identification, 'hot spot' of these metals in each wetland were mapped using Arc GIS (version 9.3) software.

ArcGIS Desktop is the primary platform for GIS professionals to compile, use and manage geographic information. Mapping has been done with ArcMap. The analysed data of the study area was exported into ArcMap with its geographical coordinates and converted to map. With the symbology available in the ArcMap, the points are depicted whether they are below or above the critical limit with respect to a particular element.

Results and Discussion

The physio- chemical properties of wetland water samples are given in table-1. The water samples collected from wetlands were mostly acidic to slightly alkaline in nature with a mean value of 7.23. Wide variation in pH was observed in the wetland waters. The highest pH (7.50) was recorded in water at Narasampathi wetland and the lowest pH (6.42) was recorded at Kurichikulam wetland. The EC values of wetland waters ranged from 0.17 to 2.98 dSm^{-1}, with a mean value of 1.13 dSm^{-1}. The EC (2.98 dSm^{-1}) was highest in Perur wetland -1 and the lowest (0.17 dSm^{-1}) was observed in water sample of Muthanankulam wetland.

Distribution of Cadmium in Coimbatore urban wetland waters is depicted in figure-1. The concentration of Cd in wetland water ranged between 0.2 and 0.7 mg L^{-1}, mostly exceeding the permissible limit of drinking and irrigation waters[10,11]. The highest cadmium concentration (0.7 mg L^{-1}) and the lowest concentration (0.2 mg L^{-1}) were observed at Sulur wetland-1 and Perur wetland -1 respectively. Even though the people are not consuming the wetland water for drinking purpose, the cattle and the aquatic vegetation which consumes this water may have severe effects on long time exposure[12].

In case of Chromium, which is one of the toxic heavy metal known for its carcinogenic nature, was found to be relatively greater concentration in the Coimbatore urban wetland is given in figure-2.The concentration of Cr in wetland waters varied from 3 mg L^{-1} to 518 mg L^{-1}. The water samples collected from wetlands are exceeded the maximum permissible limits of 0.05 mg L^{-1} and 0.10 mg L^{-1} prescribed for both drinking and irrigation waters. A very high concentration of Cr was recorded in the waters of Periyakulam wetland (518 mg L^{-1}), Kurichikulam wetland (479 mg L^{-1}) and Selvapuram wetland (356 mg L^{-1}).Whereas the waters of Perur wetland-2 recorded the low concentration (3 mg L^{-1}) of Cr. The results suggested that the Cr originating from various industries, might have reached in to wetlands through surface runoff and /or leaching from soils. The high concentration of Cr in sediments suggests that the Cr had been accumulating for a long term, and the sediment because of its physiochemical properties adsorbed a large amount of Cr[13].

Table-1
Heavy metal content of Coimbatore wetland waters

Location	pH	EC (dSm^{-1})	Cd (mg L^{-1})	Cr (mg L^{-1})	Cu (mg L^{-1})	Ni (mg L^{-1})	Pb(mg L^{-1})
Sulur wetland -1	7.11	1.48	0.7	31	13	9.0	1.8
Sulur wetland -2	7.22	0.76	0.3	14	18	9.0	1.3
Singanallur wetland	7.27	0.71	0.3	46	15	9.0	1.6
Valankulam wetland	7.07	1.29	0.3	96	19	11	1.3
Kurichikulam wetland	6.42	1.36	0.3	479	19	9.0	1.4
Periyakulam wetland	7.25	1.18	0.3	518	13	33	1.2
Selvapuram wetland	7.28	1.81	0.3	356	98	18	1.8
Perur wetland -1	7.41	2.98	0.2	51	14	13	3.0
Perur wetland -2	7.35	1.39	0.5	3	1.5	8.0	1.4
Narasampathi wetland	7.50	0.19	0.3	33	1.0	7.0	0.9
Muthanankulam Wetland	7.42	0.17	0.5	42	2.3	9.0	1.6
Krishnampathi wetland	7.42	0.24	0.3	22	2.5	8.0	1.8
Mean	7.23(±0.28)	1.13(±0.80)	0.4(±0.1)	141(±192)	18(±26)	12(±7.3)	1.6(±0.5)

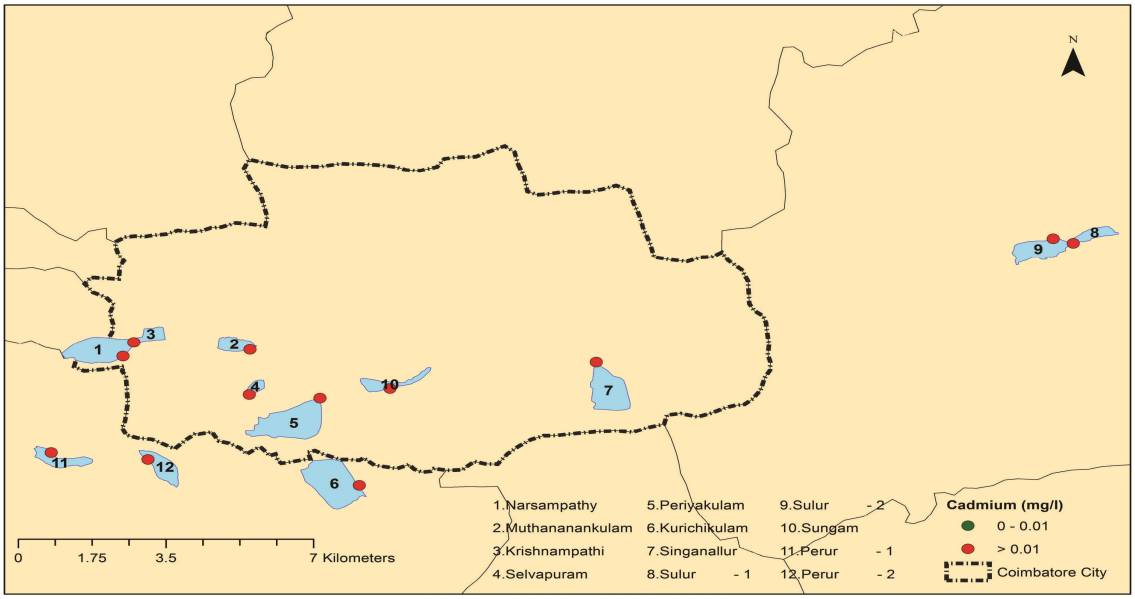

Figure-1
Cadmium Concentration in Coimbatore urban wetlands water

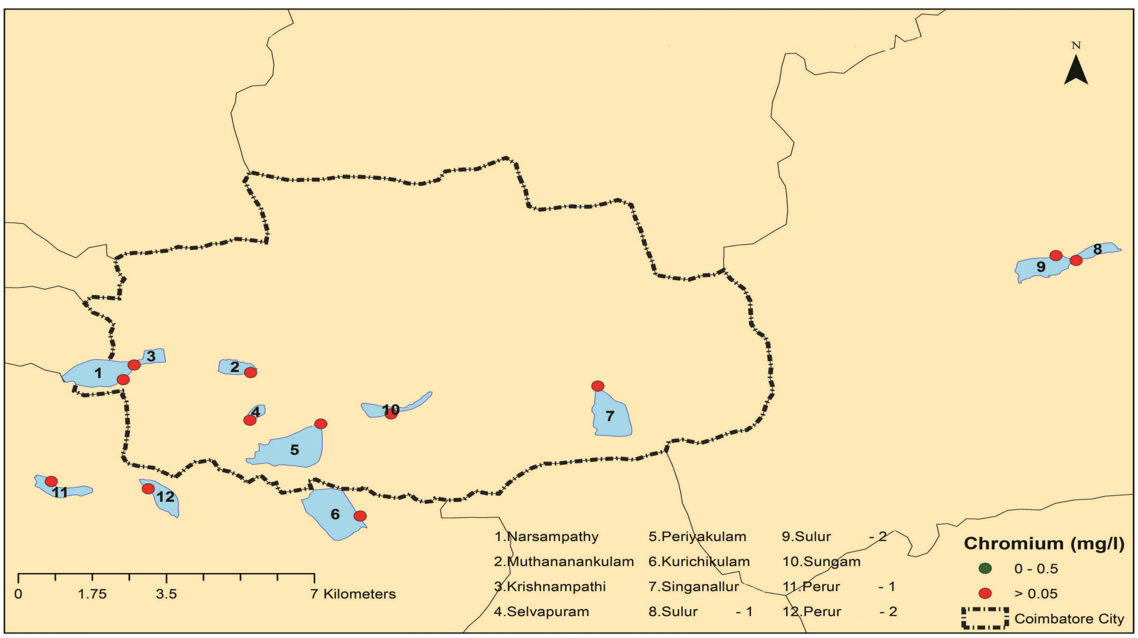

Figure -2
Chromium Concentration in Coimbatore urban wetlands water

Copper distribution in the wetland water is specified in figure-3. The copper concentration in water samples varied from 1.0 to 98 mg L^{-1} with a mean value of 18 mg L^{-1}. The lowest concentration (1.0 mg L^{-1}) was recorded at Narasampathi wetland and the highest (98 mgL^{-1}) was observed in Selvapuram wetland. The concentration of Cu in all the water samples are exceeded the maximum permissible limit prescribed by WHO. Whereas the Nickel concentration in Wetland water samples (figure - 4) varied from 7.0 to 33 mg L^{-1} with a mean value of 12 mg L^{-1}, far exceeded the maximum permissible limits of 0.02 and 0.20 mg L^{-1}, prescribed for drinking (WHO) and irrigation purposes (FAO), respectively. The highest and the lowest of Ni concentration were observed in water samples collected from the Periyakulam wetland (33 mg L^{-1}) and Narasampathi wetland (7 mg L^{-1}) respectively. The results suggested that the Ni originating from various metal based industries might have reached through the surface runoff and /or leaching from soils[14].

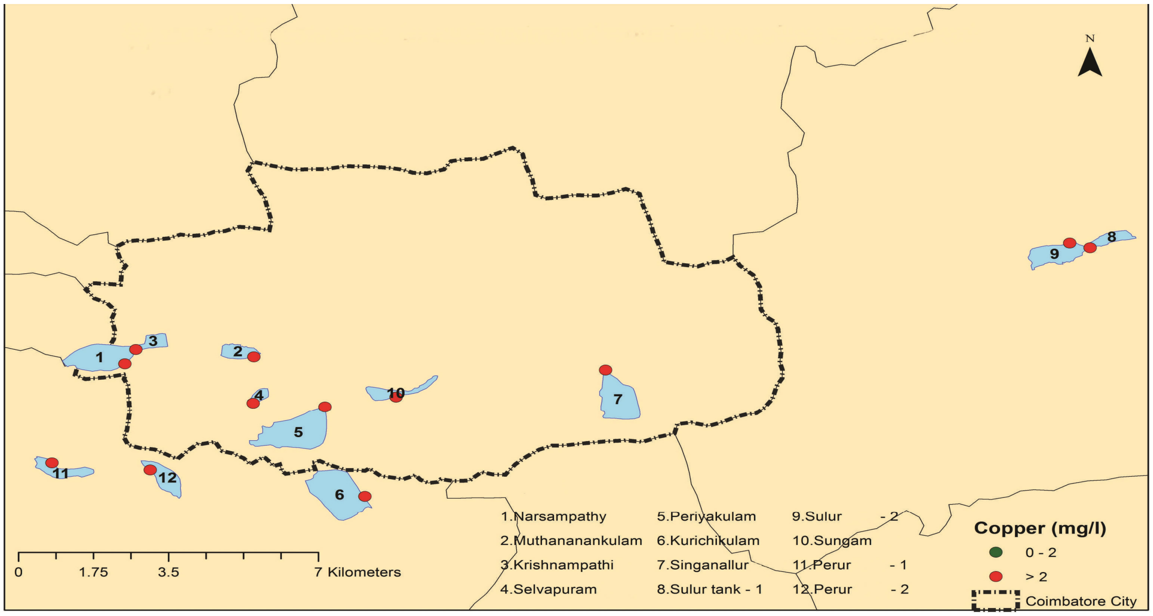

Figure -3
Copper Concentration in Coimbatore urban wetlands water

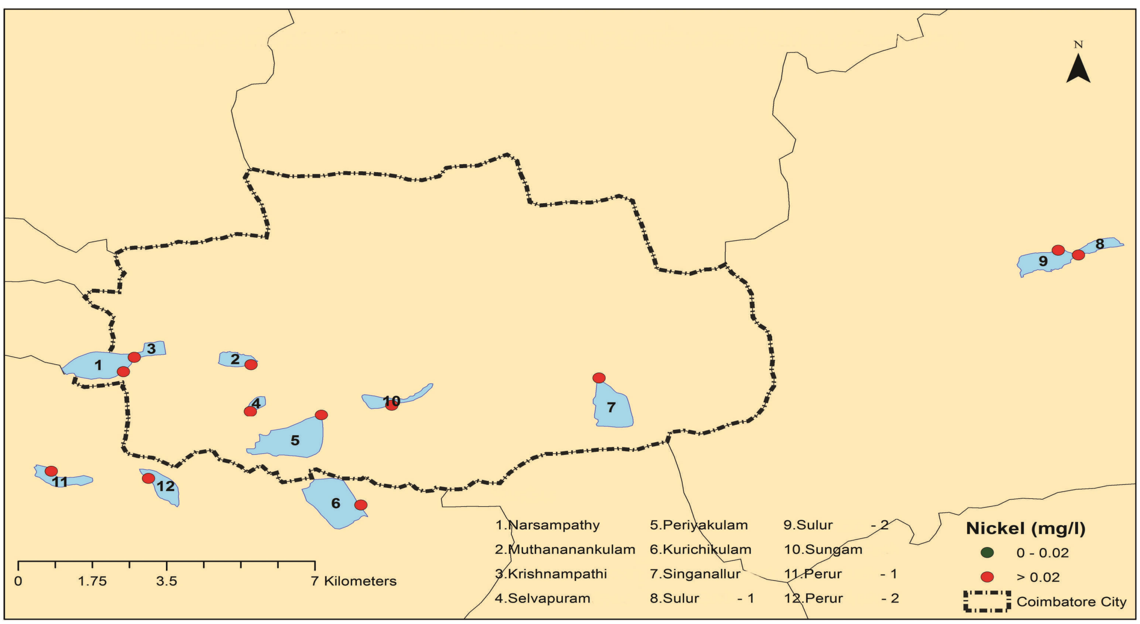

Figure -4
Nickel Concentration in Coimbatore urban wetlands water

The distribution of Lead in the wetlands is shown in figure-5. The concentration of Lead in the wetland water samples varied between 0.9 and 3.0 mg L^{-1} with a mean value of 1.6 mg L^{-1}. Perur wetland-1 shows the highest concentration (3 mg L^{-1}) of lead whereas the lowest (0.9 mg L^{-1}) was at Narasampathi Wetland. All the samples exceeded the maximum permissible limit (0.05 mg L^{-1}) prescribed for drinking water. Therefore, the waters in these wetlands are not fit for human and animal consumption. However the concentrations are well within the permissible limit (5 mg L^{-1}) prescribed for irrigation water.

Conclusion

With the results from the water analysis carried out, this study conclude that concentration of Cd, Cu, Cr, Ni and Pb exceeded the maximum critical limit prescribed for drinking water and irrigation waters. Therefore, we recommend that the water from any of the mentioned wetlands is not suitable for drinking and irrigation purpose.

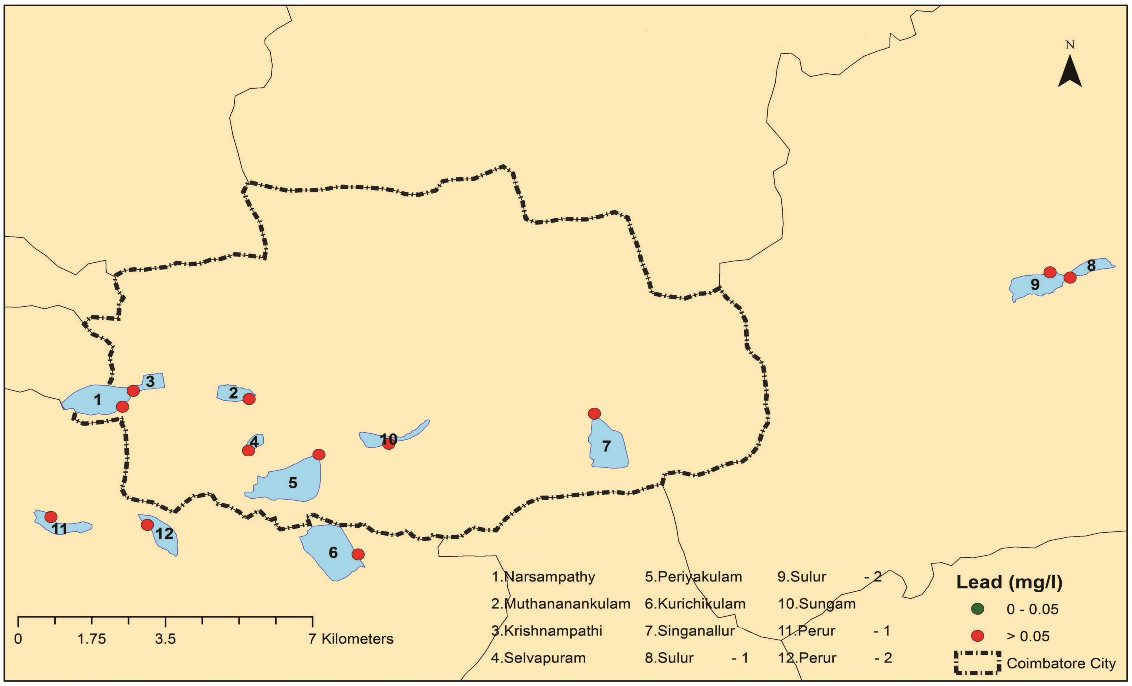

Figure -5
Lead Concentration in Coimbatore urban wetlands water

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