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Seasonal fluctuation of Heavy Metal Pollution in Surface water

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Abstract

The purpose of this study is to evaluate the heavy metal status of River Cooum, Chennai, India. In Chennai city, the increase in population rate exponentially every year, demands more consumption of water and subsequently leads to the generation of enormous quality of waste water. It can be very well noticed that the waste water is being discharged directly into the rivers of Chennai city. The present study is to evaluate quality of water in River Cooum with respect to its heavy metal concentration. This was done by monitoring the levels of heavy metals in the river water and their spatial as well as temporal distribution and variability patterns were evaluated. The assessment was made taking into account the water impact of four heavy metals: Chromium (Cr), Zinc (Zn), Copper (Cu) and Iron (Fe). Eleven water samples were analysed for four different seasons (post monsoon, summer, premonsoon and monsoon) for the year 2011. The results shows that the heavy metal concentration in water exceeded the limits prescribed by WHO.

Keywords: Heavy metals, water pollution, coum river, river pollution.

Introduction

Water is considered as a rare and valuable commodity, and only an minuscule part of the earth's water reserves (approximately 0.03%) constitutes the water resource that is available for human activities and considering growth of the world's population, industry and its demand is more than the supply available[2,3,4]. Development of civilization has led to introducing heavy metals into the natural environment in amounts remarkably excessing the natural load. Bottom sediments accumulate many elements, some of which are heavy metals, hazardous for natural environment, as well as animals and people. Environmental pollution due to contamination of river water thereby degrading the groundwater is one of the major issues in many developing countries, as the maintenance of water quality and sanitation infrastructure did not increase along with population and urbanization growth. The attention given to the presence of heavy metals in the environment is primarily due to their toxicity and threat to human life at elevated levels, and also, because of their tendency to aggravate environmental degradation. Metals are known to constitute highly persistent environmental pollutants. Thus, their tendency to remain as an environmental contaminant for a long period and to be magnified through food chains is high.

Heavy metals are the main cause of environmental pollution which can be derived from number of sources including the outfalls of sewage and industrial effluents into the river water. Though these metals are essential to human body in low concentrations, they can be toxic when the level of concentration is increased more than the prescribed limit. The quality of water mainly depends on the levels of physico-chemical parameters which play an important role in determining the quality of water.

The main sources of water pollution are chemical fertilizers and pesticides getting in an untreated sewage, dumping of waste and industrial effluents into rivers and streams running close in to the cities and to the low lands[3]. In Chennai city, the growing urbanization and rapid industrialization lead to the generation of huge quantities of waste water. The uncontrolled discharge of sewage, garbage, and industrial effluents into the downstream of the River Cooum, percolates through the soil and contaminates the Groundwater sources[5]. As per the WHO, about 80% of all the diseases in human beings are caused by impure water.

The river course gets polluted within Chennai city limits due to letting of sewage and drainage waters by slum dwellers, private parties, etc and also some industrial partly treated or untreated wastes. The colour of River water is black and sore to the eyes. The water is very unhygienic and also foul smell emanates from the waterways. The watercourse is also a breeding place for mosquitoes. The surface water quality is highly polluted due to addition of industrial and municipal wastes. The following Table 1 provides information's on the number of infalls in the waterways source wise, break-up details on industrial, commercial sewage treatment plant, pumping station, storm water outfalls. Hence, the study is intended to investigate the amount of Heavy metal pollution in the River Cooum, Chennai.

Material and Methods

Study area: The study area, River Cooum originates from Cooum tank which is situated about 65 km west of Chennai City and runs through the heart of the Chennai city for a length

of 17.98 Km and joins Bay of Bengal. The river enters in City limit near Padikuppam causeway and runs up to sea mouth below Napier Bridge for a length of 18 Km. The River serves as drainage and sewerage carrier within the Chennai city limit. Eleven stations were chosen for the collection of water samples out of which 10 were taken within the City limit. Experiments were carried out for the water samples collected during four quarters of the year 2011. A study area map comprising the points of sampling location is given in Figure 1 with the sampling stations in table 2.

Table-1
Total Number of in falls sources in the River Cooum

Description	Total number
Industrial discharge	18
Commercial	270
Sewage Treatment plant	1
Pumping Station	2
Storm water outlets	28
Slums	24
Total	**343**

Sampling Method: Samples were collected from the middle of the bridge in the river. The collected samples were transferred into suitable labelled well-dried polythene glass bottles. The collected water samples were monitored for various physical, chemical and trace/toxic elements based on the procedures described in APHA, AWWA and WPCF (1998). The physical parameters such as pH, temperature, appearance and colour, odour were recorded at the time of collection.

Table-2
Details of the sampling stations

Sampling Zone	Sample ID	Sampling location
Zone 1	SW1	Perambakkam bridge
Zone 2	SW2	Koyambed bridge
	SW3	Anna Nagar bridge
	SW4	Aminjikarai bridge
	SW5	Choolaimedu bridge
	SW6	College road bridge
	SW7	Harries bridge
	SW8	Coolaws bridge
	SW9	Periar bridge
	SW10	Quaid-E-Millath bridge
Zone 3	SW11	Napier bridge

Results and Discussion

The obtained results of heavy metals are tabulated in table 3. The results are discussed and compared with standard values. The statistical significance of heavy metals in water samples were analyzed by Analysis of Variance (ANOVA). The trends of the parameters for four seasons in the river stream for the year 2011 are shown.

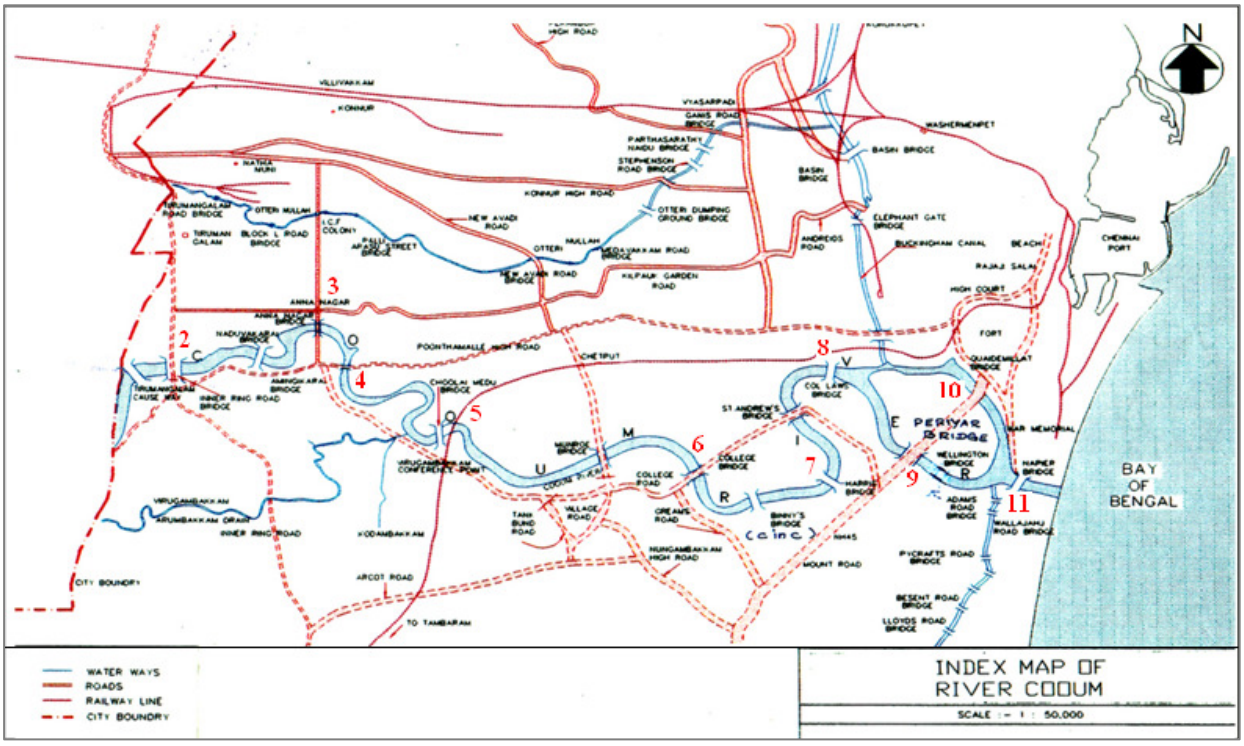
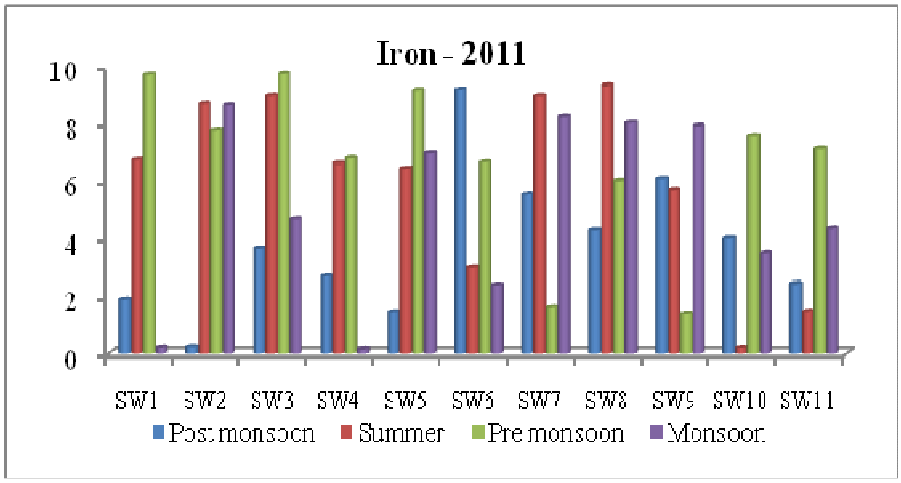
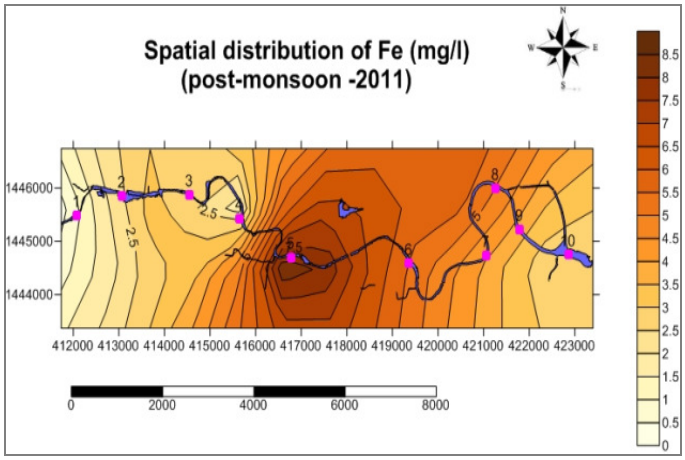
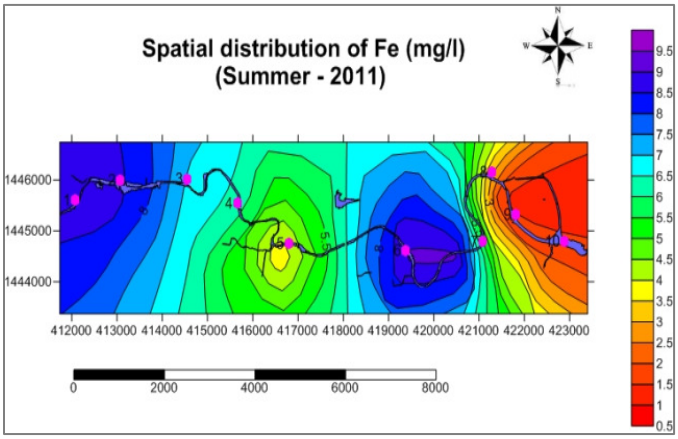


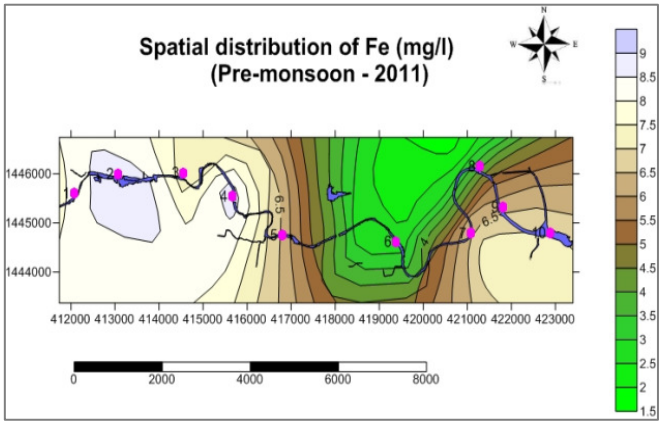
Figure-1
Study area map showing the sampling locations within the Chennai city

Iron (Fe): Iron is the second most abundant metal in the earth's crust. As per WHO the median iron concentration in rivers has been reported to be 0.7 mg/litre. The permissible limit for iron in river water is approximately 0.5 – 1ppm. Due to acute exposure, wide variations in toxicity have been reported for different iron salts. Iron content in the water samples crossed the permissible limit stipulated by WHO. The very high value of iron in this river water may be due to the result of Iron ore tailing from the metal workshops and mixing of untreated domestic and industrial wastes. Iron varied at different distances as well as in different seasons.









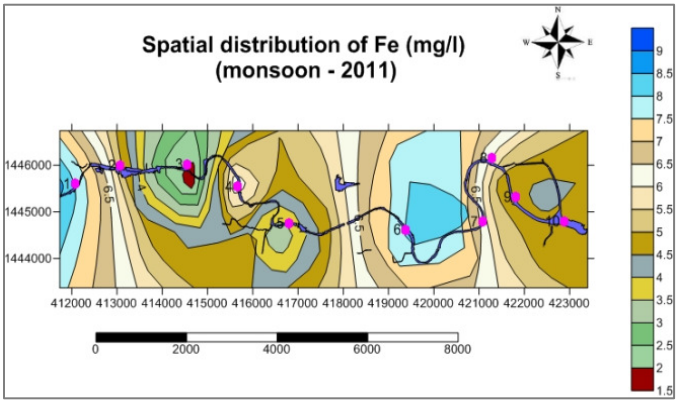


Figure-2
Seasonal variation and spatial distribution of Iron

Zinc (Zn): Zinc is an essential trace element found in river environment in the form of salts or organic complexes (WHO, 2003). The values of zinc are found in the range of 0.3 – 11.25 ppm for river water samples. Highest vale is recorded in SW5 and SW10 during summer season. Lowest value of 0.28 mg/L is recorded in the pollution free zone of SW1 and SW6 during monsoon season. Water samples during the study period showed maximum values for summer and minimum for monsoon with momentous seasonal differences. The result clearly indicates that season as well as distance has significant role in explaining the variation in zinc.

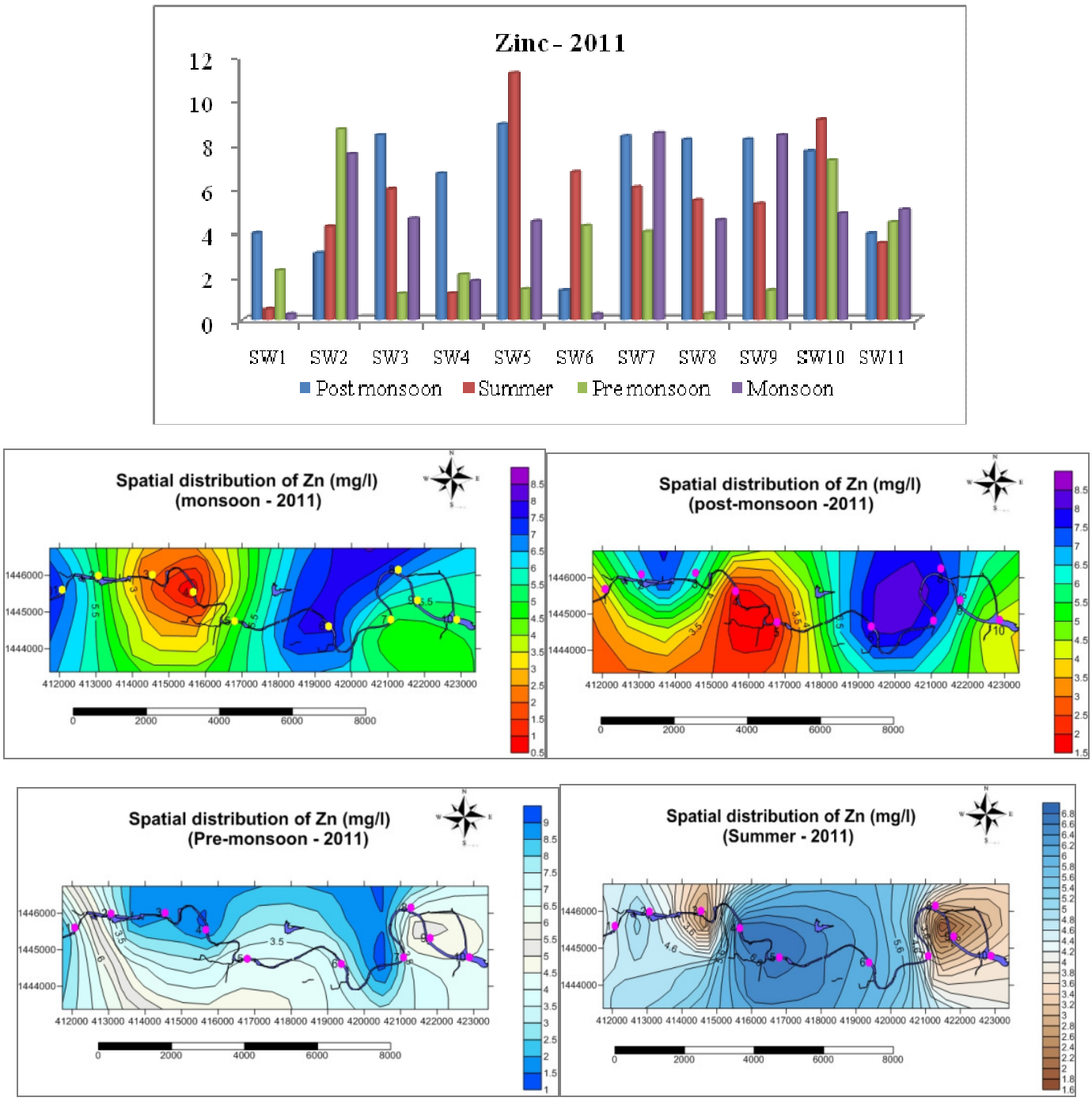


Figure-3
Seasonal variation and spatial distribution of Zinc

Copper (Cu): Copper concentrations are almost similar for all the locations of the study period with marginal variations between the seasons, although higher concentrations were observed in SW5 and SW10. High level of copper may be due to presence of industrial and domestic wastes. The alkaline pH of the medium can also be the cause of low level of copper, as heavy metals are precipitated as their salts at high pH and are deposited as sediments.

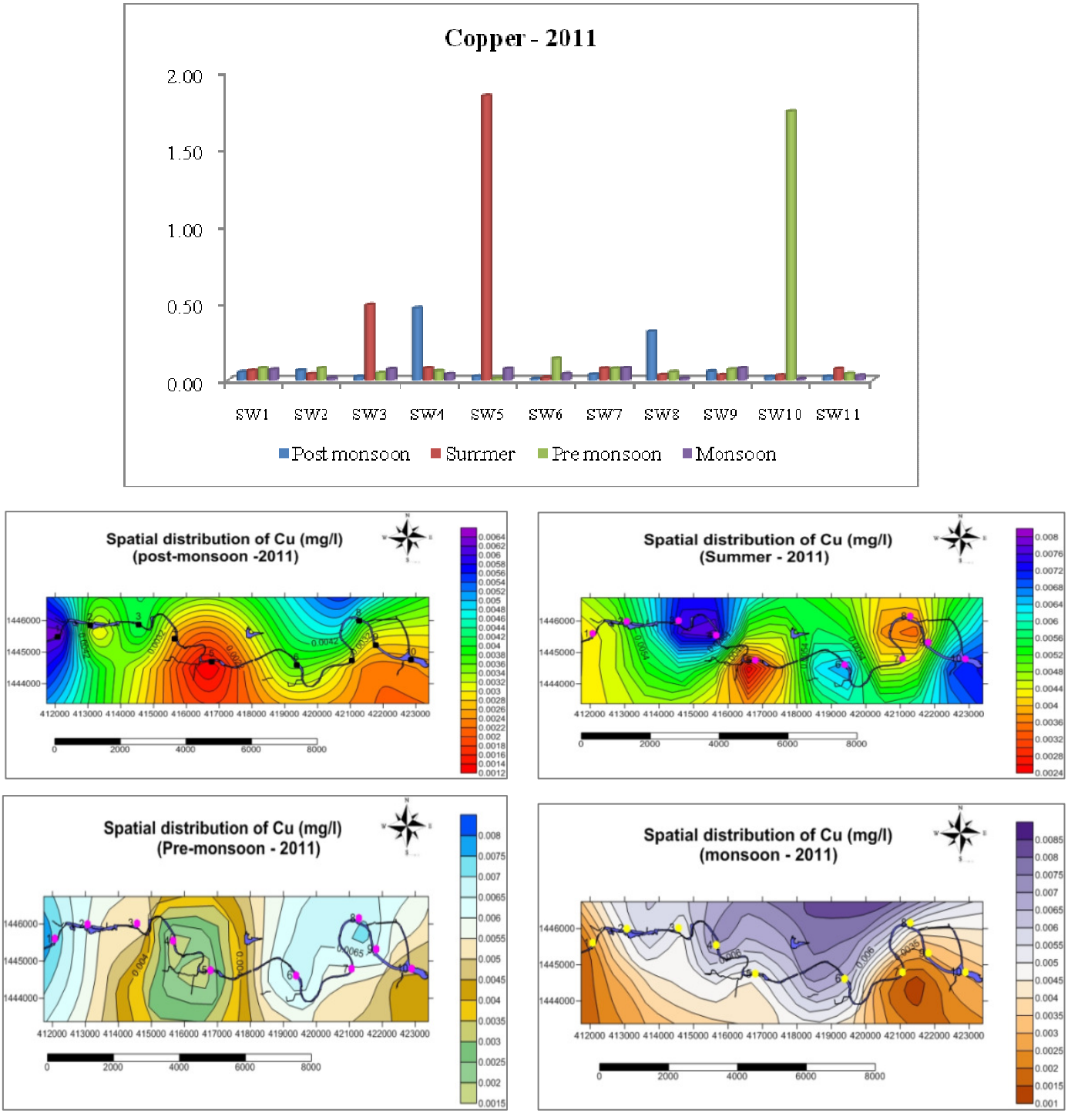


Figure-4
Seasonal variation and spatial distribution of Copper

Chromium (Cr): Chromium in water is in the form of trivalent or hexavalent state and is potentially toxic in dissolved form (Water UK, 2001). (figure 4). Higher concentration of Cr in water during post-monsoon is probably due to rain water runoff. The concentration of chromium in the study area ranges from 0.01 – 1.5 mg/L. Chromium is a specific pollutant providing evidence of industrial pollution like dye or paint operations[5]. The highest concentration of chromium was recorded in SW8 during the premonsoon and summer season. High content of Chromium may be due to various anthropogenic activities, industrial effluents, tanneries, old plumbing and household sewages[6].

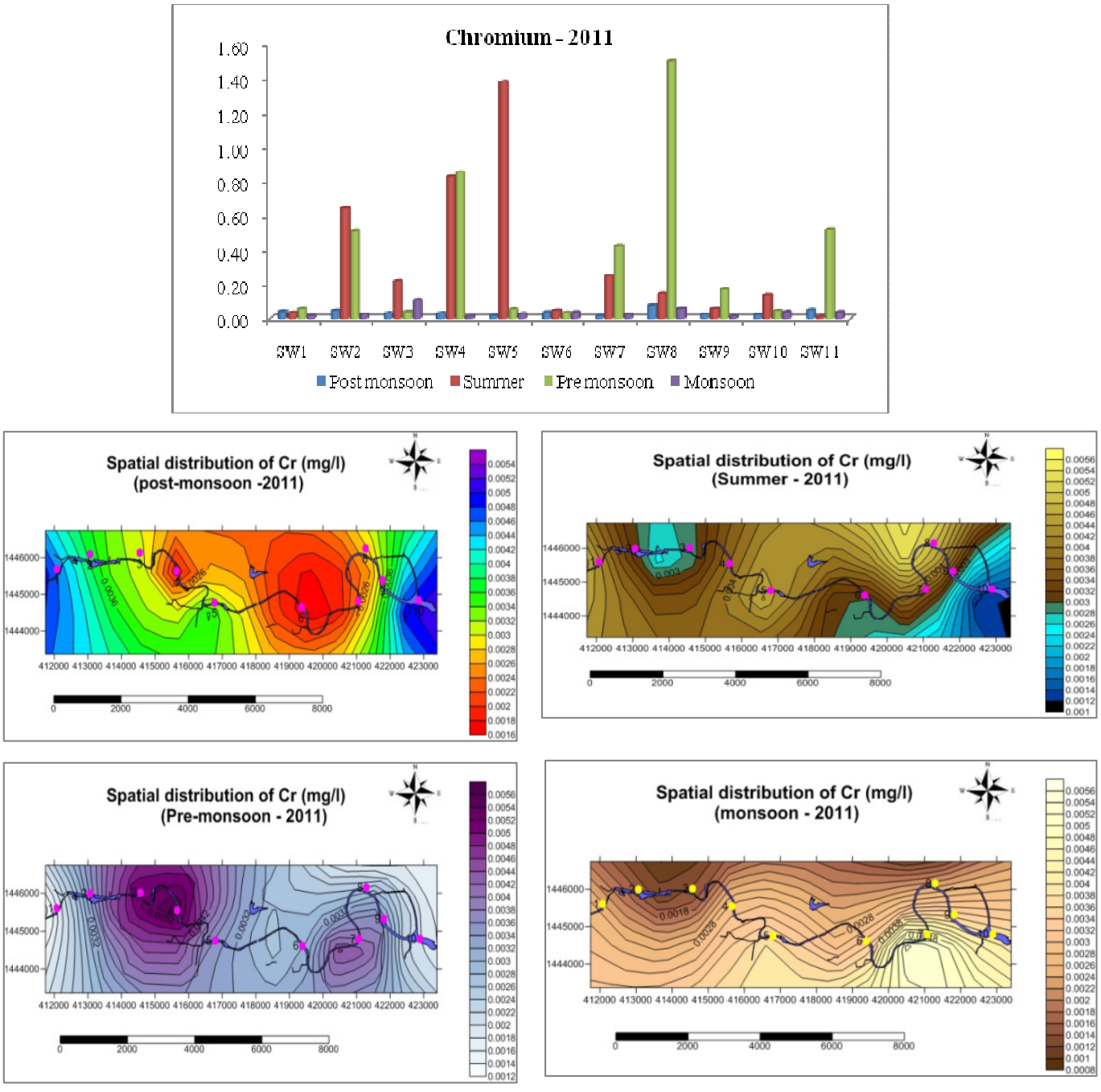


Figure-5
Seasonal variation and spatial distribution of Chromium

Table-3
Mean Concentration of heavy metal distribution in the water samples of River Cooum

S.No.	Location	Heavy metals in river water- 2011			
		Fe	Zn	Cu	Cr
1	RW1	4.655	1.763	0.066	0.039
2	RW2	6.370	5.905	0.050	0.309
3	RW3	6.800	5.063	0.159	0.101
4	RW4	4.080	2.945	0.163	0.431
5	RW5	6.033	6.530	0.491	0.371
6	RW6	5.333	3.165	0.053	0.040
7	RW7	6.113	6.745	0.068	0.179
8	RW8	6.938	4.635	0.105	0.446
9	RW9	5.283	5.823	0.060	0.067
10	RW10	3.843	7.268	0.454	0.063
11	RW11	3.860	4.253	0.043	0.155

Conclusion

The experimental stretch of the famous Cooum river water was taken as the target site for the present study. River water samples were taken from eleven sampling locations. Experiments were carried out for the water samples collected during four quarters (post monsoon, summer, premonsoon and monsoon) of the year 2011. The low concentration of heavy metals observed during monsoon could be attributed to the heavy rainfall and the higher concentration could be attributed to the number of sewerage inlets and various untreated/partially treated industrial effluents which include reside of heavy metals. From the results it is obvious that most of the groundwater adjoining the river water will also be get polluted by the percolation of the Cooum river water, dumping of waste and percolation of domestic sewage by inhabitants. The river is degraded in quality due to the industrial discharge and anthropogenic effluents. The people living on the banks of the river are more prone to infectious diseases. The eutrophication inside the river leads to the spreading of disease causing mosquitoes and other pathogens.

Due to rapid urbanization and lack of solid waste management, the river stinks and been highly polluted. But for the people in Thiruvallur district it still serves as a source of groundwater recharge. To prevent river water pollution, the sewage water which used to mix in the damp water should be diverted in to the underground drainage systems. During the rainy season the rain water harvesting in the damp is essential to reduce the impact of sewage pollution of dilution. In order to improve the quality of ground water around the damp suitable R.O. system can be used to remove salts present in the ground water.

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