CHROMIUM AND LEAD LEVEL IN THE SEDIMENT SAMPLES OF SELECTED SITES OF VAIGAI RIVER MONSOON - 2011

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ABSTRACT

The Vaigai River is one of the famous River in south part of Tamil Nadu. It irrigates six districts such as Theni, Madurai, Dindugal, Ramanathapuram, Periyakulam and Sivagangai. The peoples living in all six districts mostly depends the Vaigai River water for their livelihood in the agriculture practices. Addition to this the Vaigai River irrigates the kanmmai(Large pond), pond, oorani(Small pond) and kulam(Type of small pond) situated in all four districts. Recently the residence and different types of industries located in the Vaigai River bank due to urbanization and industrialization pollute other domestic in the agriculture purpose. Everyday several thousand liters of sewage industrial waste water discharged into Vaigai River. This practice increase the chemical load of Vaigai River in the form of heavy metals and pesticides. Hence, in the present investigation the highly toxic heavy metals such as cadmium and chromium were analysed in the sediment samples of selected sites located from Vaigai dam to all strait along the length of Vaigai River.

Keywords:

Heavy metal, Cadmium, Chromium, Vaigai River, Sediment.

Introduction

Of all the planet earth's renewable natural resources, water occupy a unique place because of its essential for sustaining all forms of life, food production, global economic development, and for the general well being. Water is also one of the most manageable of the natural resources as it is capable of diversion, transport, storage, and recycling. All these properties impart to water its great utility for human beings (Rakesh Kumar *et al.*, 2005).Water quality is considered the main factor controlling health and thestate of disease in both man and animals. Surface water quality in a region islargely determined both by natural processes (weathering and soil erosion) andby anthropogenic inputs (municipal and industrial wastewater discharge). The anthropogenic discharges constitute a constant polluting source, whereas surface runoff is a seasonal phenomenon, largely affected by climate within the basin (Singh *et al*., 2004). Hence, today, people are concerned about the qualityof the water they drink.

Degradation of water quality is caused by even though the augmentation of variety of toxic chemical, the heavy metals occupy an unique priority due to their potential toxicity for the environment and human beings (Gueu *et al.,* 2007; Lee *et al.,* 2007; Adams *et al.,* 2008;Vinodhini and Narayanan, 2008). Heavy metals are considered as critical contaminants of aquatic ecosystems due to their high potential to enter andaccumulate in food chains (Olojo *et al*, 2005; Erdoğrul, and Erbilir, 2007) andtheir ecological impact can be substantial because of their toxicity, persistence,and nondegradability in the environment (Louma, 1983; De Souza *et al*., 1986;Lacerda *et al*., 1992; Allen and Hansen, 1996, and Yang *et al*., 2009).

The accumulation of heavy metal pollutants in the water bodies only indicates the short-term pollution history. But the accumulation of these pollutant materials on sediments indicates the long-term history of pollution conditions; Riverine sediments play animportant role as pollutants and they reflect the history of the river pollution(Jain, 2004). Sediments act as both carriers and sinks for contaminants inaquatic environments. Sediments are important sinks for various pollutants like pesticides andheavy metals and also play a significant role in the remobilization of contaminants in aquatic systems under favorable conditions (Ikem *et al.*, 2003). Particularly, the river sediment is an important sink of heavy metals, but also isa secondary contamination source affecting the health of river ecosystems (Fan*et al*., 2002; Wang *et al*., 2010). Sediments play an important role in the transport of nutrients, metals, and other contaminants through river systems tothe world’s oceans and seas. Sediments also act as metal reservoirs, with the primary exchange modes being adsorption or precipitation, and can alsoprovide a reasonably accurate history of pollution in the river (Gibbs, 1977;Jain and Sharma, 2001; Filgueiras *et al*., 2002). Sediments have a high storage capacity for pollutants. In any part of thehydrological cycle far less than 1% of these are actually dissolved in the waterand more than 99% are stored in the sediments (Salomons and Stigliani, 1995). The toxic effluents and domestic sewages from variouspoint and non point sources discharged into Vaigai river containing toxicmetals, inorganic and organic compounds sink into the Vaigai river bed duringdry season. But during monsoon season due to high water flow all these toxicmaterials leached and dissolved in the water and pollute the aquatic system ofVaigai river. Addition to these the agricultural runoff containing pesticide andfertilizer also pollute the Vaigai river. The Vaigai river is the life for million of Vaigai river bed people but due to increasing pollution load the health of theriver bed people is questionable now. The periodical monitoring of pollutionstatus of the Vaigai river by government and independent research is the way toalarm the danger in front of river bed people. Hence, the present study has beenframed to heavy metals chromium and lead acuumulation in the sediments of Vaigai River from Vaigai Dam to park strait.

Materials and method

Background information about the Vaigai river

The Vaigai river is the base for the existence of Madurai, a heritage city of 2500years' history, in Tamilnadu, India.It originates in the Periyar Plateau of theWestern Ghats range. The Vaigai river rarely floods and its chief tributaries areSiruliar, Theniar, Varaha Nadi, and Mangalar. The Vaigai is 258 kilometres(160 mi) long, with a drainage basin of 7,031 square kilometres (2,715 sqmiles) large. It flows northeast through the Cumbam which lies between thePalani Hills to the north and the Varushanad Hills to the south. As it rounds theeastern corner of the Varushanad Hills, the river turns southeast, runningthrough the region of Pandya Nadu. The river empties into the Palkstrait inRamanathapuram District. In the present study, the Vaigai river from Vaigaidam to Palkstrait has been selected for investigation of persistence of heavymetals such as cadmium and chromiumin the bottom sediments…

Samples collection sites in the Vaigai river

For this study, water, sediment and fish samples were collected from 2to 6 sampling sites from each place such as Vaigai Dam, Kullapuram,Anaipatti, Sholavanthan, Thuvarimaan to Guru Theatre bridge, Madurai,Thiruppuvanam, Manamadurai, Paramakkudi and Nathipallam based on thepollution discharge area along the length of the Vaigai river. The abovementioned study sites' names and their short forms and location in the globeare given in Table 1.1.

Table 1.1 Water, sediment animal samples collection sites along the Vaigai river

Serial Number	Name of the site	Sub divisions	Location of the sample collection site	
1	Vaigai Dam	VD-1	10º 03' 18.88"N	77º 35'28.72"E
		VD-2	10º 03' 09.64"N	77º 35'23.30"E
		VD-3	10º 03' 09.04" N	77º 35' 26.90"E
2	Kullapuram	KP-1	10º 03' 11.06"N	77º39'09.37"E
		KP-2	10º 03' 22.64"N	77º 39'22.27"E
		KP-3	10º 03' 37.50" N	77º 39' 29.15"E
3	Anaipatti	AP-1	10º 05' 22.42"N	77º 51' 08.81"E
		AP-2	10º 05' 13.33"N	77º 51' 22.31"E
		AP-3	10º 05' 25.07" N	77º 51'11.30"E
4	Sholavanthan	SO-1	10º 01' 43.47"N	77º 57' 07.32"E
		SO-2	10º 01' 33.22"N	77º 57' 19.89"E
		SO-3	10º 01' 18.76" N	77º 57' 27.37" E
		SO-4	10º 01' 02.97" N	77º 57' 32.72" E
		SO-5	10º 00' 48.86" N	77º 57' 41.55" E
5	Thuvarimaan to Guru theatre bridge	TM.GB-1	09º 57' 37.44"N	78º 03' 36.73"E
		TM.GB-2	09º 57' 01.92"N	78º 04' 12.56"E
		TM.GB-3	09º 56' 40.52"N	78º 04' 52.00"E
		TM.GB-4	09º 56' 28.20"N	78º 05' 45.01"E
6	Madurai	MA-1	09º 55' 06.32"N	78º 08' 27.59"E
		MA-2	09º 55' 08.15"N	78º 08' 19.19"E
		MA-3	09º 55' 33.80" N	78º 07' 24.13" E
		MA-4	09º 56' 00.14" N	78º 06' 42.86" E
		MA-5	09º 56' 22.36" N	78º 05' 59.07" E
		MA-6	09º 54' 22.99" N	78º 09' 35.79" E

7	Thiruppuvanam	TH- 1TH- 2 TH-3	09º 49’ 46.59”N 09º 49’ 29.68”N 09º 50’ 16.95” N	78º 15’ 21.05”E 78º 16’ 07.11”E 78º 14’ 41.43” E
8	Manamadurai	MM- 1MM- 2 MM-3 MM-4 MM-5	09º 41’ 46.48”N 09º 41’ 32.76”N 09º 41’ 18.78” N 09º 41’ 03.77” N 09º 40’ 50.78” N	78º 27’ 06.92”E 78º 27’ 16.31”E 78º 27’ 25.49” E 78º 27’ 31.59” E 78º 27’ 42.72” E
9	Paramakudi	PK- 1PK- 2 PK-3 PK-4 PK-5	09º 34’ 16.43”N 09º 33’ 45.97”N 09º 33’ 20.02” N 09º 32’ 55.49” N 09º 32’ 16.97” N	78º 33’ 37.74”E 78º 34’ 18.59”E 78º 35’ 00.81” E 78º 35’ 43.18” E 78º 36’ 16.11”E
10	Nadhipalam	NP- 1NP- 2 NP-3	09º 20’ 57.47”N 09º 20’ 46.57”N 09º 20’ 33.65” N	78º 56’ 47.71”E 78º 57’ 00.40”E 78º 57’ 10.54” E

Work design

The Vaigai river is 258 kilometer long from its place of origin to itsmouth on Palkstrait. The Vaigai river from Vaigai dam to Palkstrait has beenconsidered for present study. Totally, 10 locations including 40 sites wereselected for the present study, along the length of the Vaigai river. Sediment samples were collected from eachstudy site. The accumulation of heavy metals such as cadmium and chromium from each sample sitehas been studied.

Method of sample collection

Sample collection location and period

The sediment samples were collected in metallic core-liner from all 40sample sites along the length of the Vaigai river during the month of December(monsoon period) 2011. The first day sample collection trip was made on 11thDecember in VD-1, VD-2 and VD-3 near Vaigai dam, KP-1, KP-2 and KP-3near Kullapuram, AP-1, AP-2 and AP-3 near Anaippatti, SO-1, SO-2, SO-3,SO-4 and SO-5 near Sholavanthan, and TM.GB-1, TM.GB-2, TM.GB-3 andTM.GB-4 near Thuvarimaann to Guru Theatre bridge. In the second day, 12thDecember 2011, the sample collections were done at sample sites MA-1, MA-2, MA-3, MA-4, MA-5 and MA-6 in Madurai, TH-1, TH-2 and TH-3 nearThiruppuvanum, MM-1, MM-2, MM-3, MM-4 and MM-5 near Manamadurai, PK-1, PK-2, PK-3, PK-4 and PK-5 near Paramakudi, and NP-1, NP2 and NP-3near Nathipalam.

Labeling the samples bottle for identification

The sample details such as collection site, date and time were marked bypermanent glass marker containing indelible ink directly on the samplecollection bottle.

Sediment collection site selection

In general, the finer and more polluted sediments will deposit alongthe edge of a river channel, on the inside edge of a curve in a river and on thedown drift side of river. All these points were considered for the selection ofsediment sample collection site. In the present study, the sediments werecollected only in the places near to human settlement along the length of theVaigai river. The location of sampling site was defined by Google earth maplink 2011 and visual estimates.

Sediment collection methods

Core sampling method was selected for the present study. The stainlesscorer has 2 inch inside diameter and 4 ft length with CAB plastic liner is used.During the time of sampling, the core sampler was allowed to fall from acertain distance above bottom. After landing the core sampler on the sedimentbottom, the sediments were automatically loaded inside the corer and after 10minutes the core sampler was lifted out from the water. The samples lodged inside the corer was separated and transfered to metallic made core liner whichis capped at both ends. The core liner was labeled to identify the top andbottom of the core. Actually the sample testing laboratory is at 2-150kilometers distance from the sample sites and so immediate analysis isimpossible and delayed analysis leads to the degrading of quality of results. Toavoid all such problems the samples were placed in an ice chest with wet icefor storage. The temperature was maintained at approximately 4ºC to preventbiological activity and unwanted chemical reactions.

Processing of sediment samples for heavy metal analysis

The sediments taken out from the ice chest was dried, ground, andhomogenized. They were then sieved through a 2 mm stainless steel mesh. 0.5gof the resulting homogenous sample was weighed into a 120 ml of acid cleanedTeflon microwave vessel. 5ml of ultra pure nitric acid and 2ml ultra purehydrofluoric acid were added and digested for 30min at 200°C. After allowingat least 2h for cooling, the vessels were opened and 0.8g boric acid was addedto dissolve the fluoride precipitates. The final volume was made-up to 50 ml bydeionized water and taken to detect the heavy metals by Atomic AbsorptionSpectrometer.

RESULT AND DISCUSSION

The Vaigai river irrigates the 7,000 -sq-km area covering four districtsTheni, Madurai, Sivagangai and Ramanathapuram in Tamil Nadu. It increasesthe ground water level in the riverbank during flowing period. This river isseasonal one. The water for the Vaigai river comes from various sources like itschief tributaries such as Suruliar, Theniar, Varaha Nadhi, and Manjalar. It flowsthrough a length of 150 miles (240-km), generally southeast. The western andnorthwestern parts of the basin receive heavy rainfall during the monsoons,with an average rainfall of 850mm over the basin. This rain fall is the mainreason for flood in the Vaigai river. The Vaigai river from Vaigai dam to PalkStrait crosses many cities, towns and villages. During dry seasons, the household domestic waste and sewage water released from these cities, towns andvillages as a non point and point source and the effluents from industries are letinto the Vaigai river. This waste water is mostly chemicals and metal rich innature. They are easily dried up by sunlight or absorbed by sand bottom of theriver. The chemicals and metals in the waste water persist as a residue in thesand. But during rainy seasons, these chemical and metals immediatelydissolve in the water and contaminate the ground water and the river water.

Hence for the present investigation, the sediment and animal sampleshave been collected from different selected sites along the Vaigai river fromVaigai Dam to Palk straight to evaluate heavy metals pollution in the Vaigairiver.The main sources of pollution of the Vaigai river are urban, agriculturaland industrial waste waters. Industrial waste waters and sewage of metropolitancentres, small electroplating workshops, repair shops, hospitals, medical andscientific laboratories, as well as surface runoff of cities are the main sources ofsuch urban wastewaters (Babich and Stotsky, 1982). The residents who areliving in the Vaigai river bed dump millions of tonnes of waste water into theVaigai river every day as domestic wastes and sewagewater by their anthropogenic activities. Due to this reason, the Vaigai riverwater is turned into black colour, dead and unfit for human consumption inmany places. The river plays a major role in assimilation of carrying offmunicipal and industrial wastewater and runoff from agricultural land. Themunicipal and industrial wastewater discharge constitute a constant pollutingsource, where as the surface run-off is a seasonal phenomenon. Seasonalvariations in rainfall, surface run-off, interflow, ground water flow and pumped in and outflows have strong effects on river discharge and subsequently on theconcentration of pollutants in river water (Vega *et al*., 1998).Sediments are known to accumulate trace metals in aquatic ecosystems.It acts as storage sinks for various pollutants. If the storage function overtakesits role, they cause problems such as pollution. This is particularly true ofdepositional sediments in close proximity to anthropogenic metal discharges.

The chemical composition of the sediments can be used as a powerful tool todetermine the provenance (Vital and Stattegger, 2000). Sediments can besensitive indicators for monitoring contaminants in aquatic environments. Thesediments were polluted with various kinds of hazardous and toxic substances(Kamaruzzaman *et al*., 2011). Sediments can also act as a scavenger agent forheavy metal and an adsorptive sink in aquatic environment. It is thereforeconsidered to be an appropriate indicator of heavy metal pollution (Idris *et al*.,2007). Determination of metal concentrations in suspended and bed sedimentsis more sensitive than the dissolved concentrations as indicators ofcontamination in hydrologic system (Salmons and Forstner, 1984; Luoma,1990). Sediments not only act as the carrier of contaminants, but also as thepotential secondary sources of contaminants in aquatic system (Calmano *et al*.,1990; Salomons and Forstner, 1984). Such sediments may become so elevatedin trace metals that they pose a risk to the associated benthic biota. For organisms closely associated with surface sediments, the uptake of metals mayresult from exposure to the overlying water, the sediment pore-water,sediment/food ingestion, or a combination of the three (Ankley, 1996; Lee *etal*., 2000). Hence, In the Vaigai river, the sediment, were taken from 40 sites located in 10 different locations andthey were analyzed for some selected heavy metals to estimate contamiantion of Vaigai River.

In this study, concentrations of cadmium in sediments, of the Vaigai river system is determined from all forty sediment samples. The mean value for every sample site along the length of theVaigai river from Vaigai dam to Palk strait are reported in Table **1-10** and thegraphical forms of the result are shown in Figure **1-2**.In India, various levels of cadmium concentration have been reported tobe present in aquatic ecosystem which is more than 5ng/ml in the Yamuna riverwater at Agra, Delhi, Etawah and Mathura (Ajmal *et al.*,1985) and 0.50-114.8mg/kg in the Yamuna river sediments at Agra and Delhi but the water aroundthe industrial areas have been found to contain higher levels of cadmium (Singh, 2001 and Kaushik *et al.*, 2003). Similarly, the Vaigai river also hasbeen contaminated with the heavy metal cadmium. Moreover, the maximumand the minimum mean levels of Cd in sediment samples obtained from theVaigai river system ranged from 9.66±1.27mg/kg to 4.22±0.52mg/kg for all theforty sediment sampling points as placed in Table **1-10**; Fig **1-2**. The highestlevel of cadmium in sediment was obtained at sampling point MA-5 (nearMadurai city) and the lowest at sampling point KP-2 (Vaigai river nearKullapuram) as depicted in the Table **1-10**. The mean Cd concentrationsobtained for all these forty sediment samples are many fold higher than theGESAMP (Joint Group of Experts on the Scientific Aspects of MarinePollution) recommended threshold limit 0. 11mg/kg. The cadmiumconcentrations in the sediment sample sites VD-I, VD-2, VD-3, KP-1, KP-2,KP-3, AP-1, AP-2, AP-3, TH-1.TH-2, TH-3, NP-1, NP-2 and NP-3 are verynear to the minimum range value because all these are sites located in theindustrial free and residential free areas. Even though, the cadmium level ismanifold higher than the WHO recommended threshold, this may be due to therunoff that come from the fertilizer utilizing agricultural land. The runoff andwaste water come from the nearby agricultural land situated on both sides ofthe river bed into the Vaigai river during the time of heavy rain augment thehighest cadmium in the sediments. Trace metal enrichment in soil by mineralfertilizers is the most documented for cadmium (Cd) and was first identified inAustralia (Williams and David, 1973). The retrospective analysis of archivedsoil samples from Rothamsted (UK) unequivocally showed that long-term phosphorus (P) fertilizer application was a major source of Cd in soil (Jones *etal*., 1987a). The most likely origin of the excess Cd is from heavy applicationsof cheap, contaminated phosphate fertilizers (Booth, 2005; Stephens andCalder, 2005). This agricultural runoff increases the cadmium concentration inthe Vaigai river surface water which was collected from the sample siteslocated in the industrial and residents-free remote areas.

Chromium compounds are mostly produced in two forms from thechemical industry. They are chromium (III) and chromium (VI) which are usedin chrome plating, leather tanning, wood preserving and the manufacture ofdyes, pigments, alloy formation and steel works (Shanker *et al.*, 2005; Ryan *etal*., 2002). From all these industries, large quantities of chromium compoundsare discharged into the waterways in the form of liquid, solid, and gaseouswastes. Chromium is an essential trace metal for living organisms (Anderson,1997; Cefalu and Hu, 2004).Trivalent chromium (Cr (III)) compounds arenecessary to drive sugar and lipid metabolism in human at trace amount whileCr (III) is not readily absorbed into the human body (Katz and Salem, 1993).However, it shows a high toxicity, that renders it hazardous even at very lowconcentration (20µg/l) (EPA, 1998; Cheung and Gu, 2003). Cr(VI) is relativelymobile, readily soluble in water, generally more bioavailable than Cr(III) andcan easily permeate the biological membranes (Mugo and. Orians,1993; Kazi*et al.*, 2008) and can enter the cell where it is chemically transformed into themore stable Cr (III) form. Inside the human cell, Cr(III)can damage the DNA.Hexavalent chromium (Cr (VI)) is also extremely toxic and carcinogenic owingto its ability to oxidize other species [EQSWP, ;Nriagu and Nieboer,1998;Kota´s, 2000). These high toxic chromium compounds are dumped into theVaigai river in huge amount every day along with household sewage andindustrial discharge. This was evidenced by the obtained high level chromiumcontent in the sediment, water and animal samples collected from all the fortysites along the length of the Vaigai river from Vaigai dam to Palk Strait. Theminimum and the maximum range of chromium concentration in the sedimentsamples of all the forty sites of the Vaigai river show 19.12±2.12mg/kg and46.25±5.57mg/kg which is 0.53±0.35µg/l. The above mentionedmaximum ranges of chromium in the sediments of the selected sites of theVaigai river may be due to the releasing of effluents from chromium platingindustry, gold jewels making places (gold smith workshops), steel work, woodprocessing and dye industries. Chromium is extensively used in electroplating,paint and pigment manufacturing, textile, fertilizer and leather tanningindustries that discharge the trivalent and hexavalent chromium with wasteeffluent to the soil and surface water (Ganguli and Tripathi, 2002).

The minimum sediment chromium range 19.12±2.12mg/kg observed inthe Vaigai river is merely three fold lower than the TEC (Threshold EffectConcentration) 43.4 mg/kg and many fold lower than the PEC (Probable Effectconcentration) 111mg/kg suggested by Mac Donald *et al.*, (2000). Themaximum range 46.25±5.57mg/kg was more or less equal to the TEC andlower than the PEC. Consensus based sediment quality guidelines for freshwater ecosystem developed by Mac Donald *et al.*, (2000) recommended TEL(Threshold Effect Concentration) is 35.7 mg/kg, LEL (Lowest Effect Level) is16mg/kg, MET (Minimal Effect Threshold) is 28 mg/kg, ERL (Effect rangeLow) is 70 mg/kg and TEC(Threshold Effect Concentration) is 31.6mg/kg inthe sediments of drinking water. The minimum and the maximum rangesobserved in the sediment samples of all sites of the Vaigai river show someassociation with the chromium levels

6.8 to 35.0mgkg−1 observed in theYamuna river sediments by Kaushik *et al.,* (2009) and 40.34μg/g in thesediments of the Chakighera river bed (Abdul Rauf1 *et al.*, 2009).

Summary

The Vaigai River is one of the most important watersheds in TamilNadu State, India. It runs across many villages, small towns and large cities offive districts. Over 50% of the people along the Vaigai river basins get drinkingwater from the ground water below the Vaigai river basins. Further, the Vaigaidam, located in the upper reach of the Vaigai river, provides water supply forcultivation of paddy twice in a year and some for other agriculture purposes bydirect link. At the same time, through the indirect link like Kanmai(large pond), Oorani (small pond) and Kulam (type of small pond) the Vaigai river provideswater supply for 60% of agricultural lands located in all six Theni, Madurai,Dindigul, Sivagangai, Madurai and Ramanathapuram districts. Therefore, theVaigai river and its tributaries are crucial for all six district residents for social,economic, community health and recreations. In this situation, if any negativechanges occur in the water quality of the Vaigai river, it reflects their negativeimpact on aquatic fauna and flora of the Vaigai river and the tanks, and pondsdepends upon by the Vaigai river Through food chain, it reaches the humanbody and creats various health hazardous effects. Hence the present study hasbeen carried out to check important toxic metals cadmium and chromium in the Vaigai River sediments to areas the toxicity nature of Vaigai River.

Table 1. Heavy metals concentration(mg/kg) in the sediment samples of Vaigam Dam, Kullapuram, Anaipatti and Sholavanthan sites ofVaigaiRivernear Vaigai Dam,Maduraicity.

Metals	Sample Sites													
	VD-1	**VD-2**	**VD-3**	**KP-1**	**KP-2**	**KP-3**	**AP-1**	**AP-2**	**AP-3**	**SO-1**	**SO-2**	**SO-3**	**SO-4**	**SO-5**
Cadmium	**6.33±0.59**	**7.09±1.07**	**7.29±0.74**	**5.04±0.30**	**4.22±0.52**	**4.37±0.24**	**5.35±0.71**	**6.38±0.70**	**6.56±0.59**	**7.61±0.64**	**8.24±0.87**	**8.58±0.86**	**8.38±0.81**	**8.5±1.17**
Chromium	**27.66±3.51**	**26.14±4.58**	**29.43±5.51**	**23.3±3.61**	**19.12±2.12**	**20.33±3.06**	**19.67±2.52**	**21.11±2**	**21.75±3.51**	**33.18±4.58**	**36.61±4.04**	**38.37±5.13**	**32.63±5.03**	**37.41±5.57**

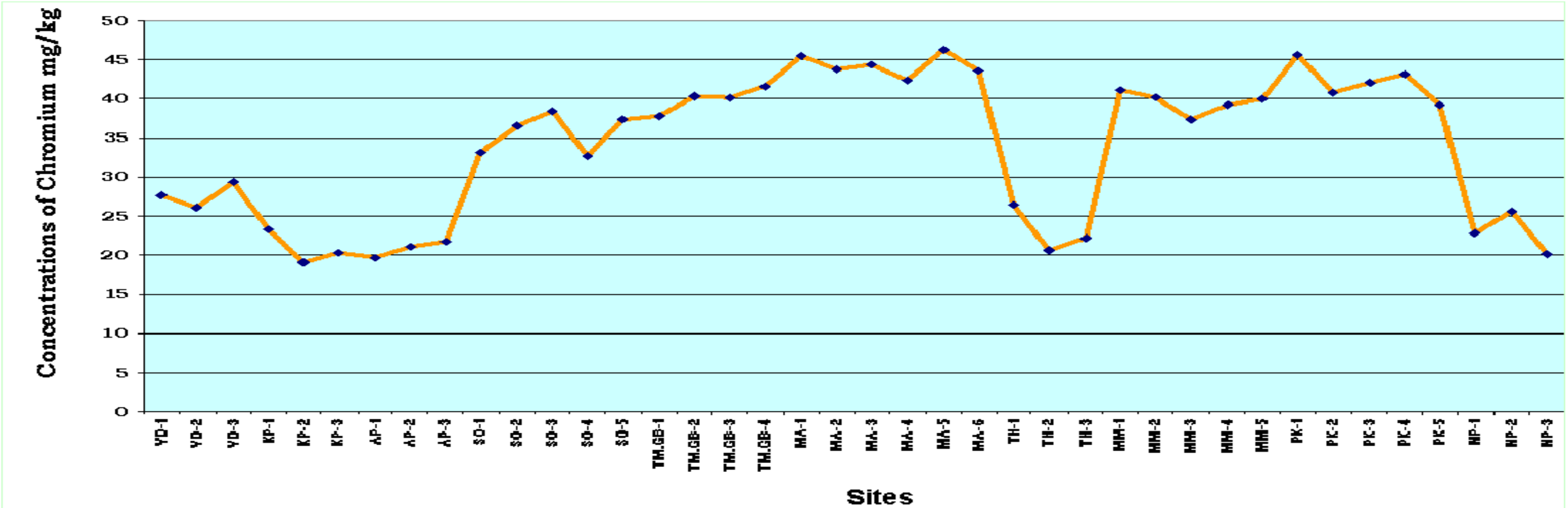
Table 2. Heavy metals concentration(mg/kg) in the sediment samples of Thuvariman, Madurai City and Thiruppuvanam sites ofVaigaiRivernear Vaigai Dam,Maduraicity.

Metals	Sample Sites												
	MM-1	**MM-2**	**MM-3**	**MM-4**	**MM-5**	**PK-1**	**PK-2**	**PK-3**	**PK-4**	**PK-5**	**NP-1**	**NP-2**	**NP-3**
Cadmium	**8.57±0.62**	**9.24±0.45**	**8.31±1.16**	**8.84±0.99**	**8.29±1.00**	**8.24±0.97**	**8.40±0.72**	**8.57±0.63**	**7.35±0.54**	**8.74±1.25**	**6.49±0.79**	**6.67±0.62**	**6.21±1.31**
Chromium	**41.15±4**	**40.13±6.03**	**37.28±5.51**	**39.16±4.23**	**40.05±5**	**45.65±5.51**	**40.79±3.51**	**41.97±4.73**	**43.08±4.58**	**39.27±5.57**	**22.77±4.16**	**25.65±4.04**	**20.18±5.57**

Table 3. Heavy metals concentration(mg/kg) in the sediment samples of manamaduerai, Paramakudi and Ramanthapuram sites ofVaigaiRivernear Vaigai Dam,Maduraicity.

Metals	Sample Sites												
	TM-GB-1	**TM-GB-2**	**TM-GB-3**	**TM-GB-4**	**MA-1**	**MA -2**	**MA-3**	**MA-4**	**MA-5**	**MA-6**	**TH-1**	**TH-2**	**TH-3**
Cadmium	**7.57 ±0.62**	**9.24± 0.45**	**8.31± 1.16**	**8.24± 0.87**	**9.14±1.22**	**9.23± 0.86**	**9.51±0.90**	**9.45± 0.63**	**9.66± 1.27**	**9.08 ±1.46**	**6.42± 0.84**	**6.27± 1.03**	**6.64± 0.65**
Chromium	**37.85 ±4.58**	**40.32 ±3.15**	**40.23 ±5.03**	**41.59 ±3.06**	**45.51 ±6.56**	**43.68 ±7.02**	**44.37 ±6.03**	**42.34 ±6.56**	**46.25 ±5.57**	**43.67 ±6.03**	**26.43 ±5.03**	**20.67 ±2.52**	**22.16 ±3.61**

Fig.1. Fluctuation of mean cadmium concentrations in the sediment of all smaple sites furing November-2011.



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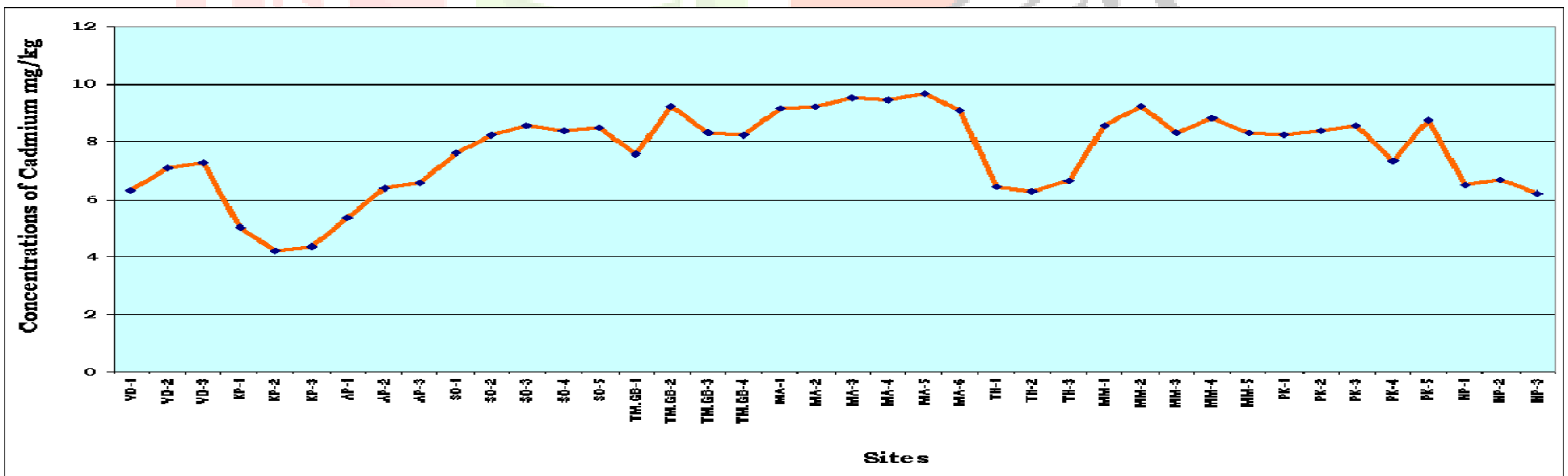

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