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Research article

HEAVY METAL CONTAMINATIONS IN SAGAR LAKE AND DRINKING WATER SOURCES OF SAGAR CITY

Nahid Parveen* and Y. Rohan

Dept. Of Chem. Dr. H.S. Gour V.V. Sagar (M.P.) 470003, INDIA

parveen.nahid@yahoo.com

ABSTRACT : There are various toxic elements present in our surroundings out of that the toxic heavy metals Pb, Cd, As, Se, Cr and Cu can cause several harms to human these metals enter in humans by water. The all kind of waste materials are thrown into natural water bodies in each city, this makes the all ground and natural water sources contaminated. The all six metals have determined by Atomic absorption spectrophotometer(AAS) in selected water samples from Sagar Lake and dug wells, hand pumps, tube wells etc. during Jan.2009 to June 2010 in every month the all most all sample have higher metal concentrations than their prescribed permissible limits by WHO.

Key words: heavy metals, AAS, lake water, ground water, natural water

INTRODUCTION

There are a large number of materials, including metals, non–metals, hydrocarbons, ions and various gases which pollute the atmosphere. Among all, the heavy metals are discharged by industries into air, water and soil (M.B. Arian et al 2008, R. Rajavel et al 2009). They get into human food chain from the environment (R. B. Solanki and C. P. Sawant, 2009, K. L. Patil and C. P. Sawant, 2009). These elements enter our biological system and disturb the biochemical processes, leading in some cases to fatal results (K. Yuan and Y. Lin, 2009).

Many of the sediments in our rivers, lakes and oceans have been contaminated by pollutants. Some of these pollutants are directly discharged by industrial plants and municipal sewage treatment plants others comes from polluted runoff in urban and small scale industries and workshop's areas and some are the result of historical contamination (S. Yerel, 2009, H. Ciftci and E. Karpta , 2009). Contaminated sediment can threaten creatures in the benthic environment exposing worms, crustaceans and insects to hazardous concentrations of toxic sediments kill benthic organism, reducing the food available to larger animals such as fish (F. Koc et al, 2009). Some contaminants in the sediments are taken up by benthic organism in a process called bioaccumulation (A.A. Ramadan et al 2009). When larger animals feed on these contaminated organisms the toxins are taken into their bodies, moving up the food chain in increasing concentration in a process called as biomagnifications which affects the aquatic flora and fauna. The marine water or fresh water may accumulate hazardous level of toxic chemicals contaminated sediments that never always remains at the bottom of a water body. Anything that stirs up the water such as dredging, can re suspend sediments. Re suspension may mean that all of the animals in the water, and not just the bottom, dwelling organism, will be directly exposed to toxic contaminants ([10].

The present work is centered to the Lake of Sagar and drinking water sources like dug wells, tube wells near and around Lake of Sagar city and automobile garages, denting-painting, workshops etc. Almost ¾ part of Sagar Lake is surrounded by roads and dwelling units like huts or houses. So the two most important sources of pollution are heavy traffic and domestic waste which are drained into lake directly. The traffic is always in action and gives their exhaust waste gases to the air and atmosphere of the lake and all these gases are settled by raining and sedimentation into the lake. Due to this the water sources like hand pumps, dug wells, domestic tube wells are also vulnerable to assimilate the pollutant into the water by capillary absorption [11].

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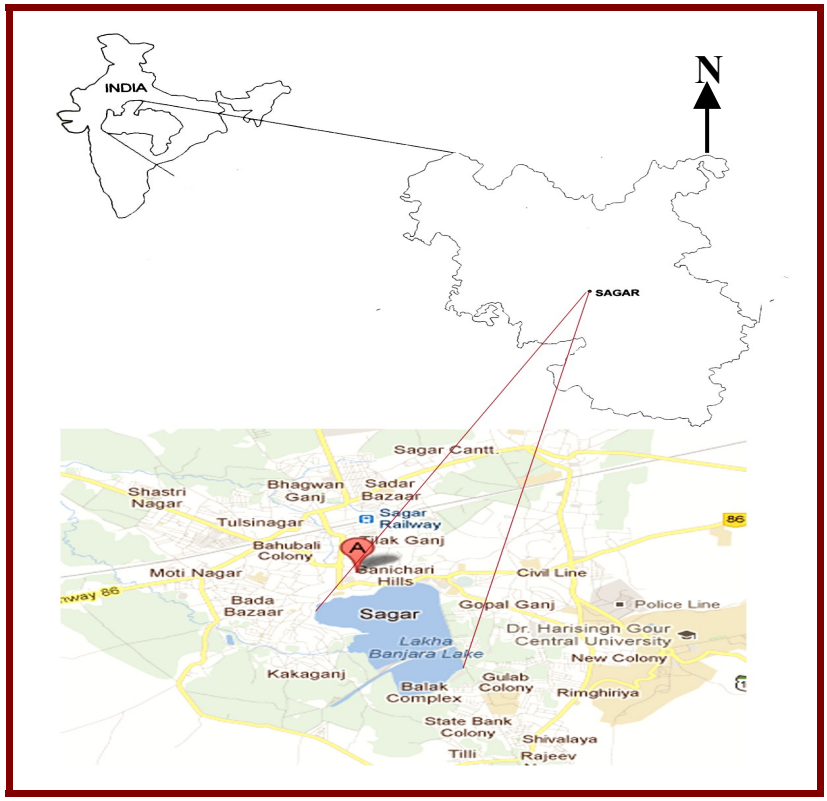
The workers who works at the garages and other work shops like painting industries are also exposed to intake these heavy metals by inhalation or direct contact due to zero precaution while handling or working above optimum conditions [12]. So the water of lake and other drinking water sources, aquatic plants, aquatic animals, soil, worker of garages all are having the possibility of in taking heavy metals directly or indirectly[13, 14].

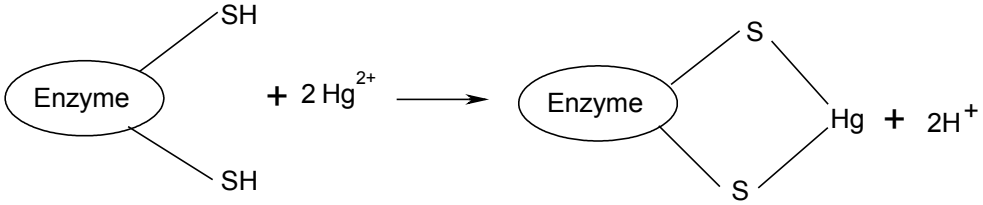


Map 1: Map of sampling locations – Sagar Lake, Bhagwan Ganj, Tilak Ganj and near Apsara Talkies (Tulsi Nagar) Area

Toxic substances may be classified according to their functions and effects, such as mutagens, Carcinogens etc. or food, additives etc. or heavy metals [23]. Table 1 shows some toxic metals and their sources of occurrence and effects [24, 25].

IMPACT OF TOXIC CHEMICAL ON ENZYMES

Generally heavy metals like Hg^{2+}, Pb^{2+}, Cd^{2+}, Zn^{2+}, As^{3+} act as enzyme inhibitors because these metals have the tendency for sulphur containing ligands like –SH and $–S-CH_3$ in cysteine and methionine.



Since metalloenzyme contains metal when one metal ion of a metalloenzyme is replaced by other foreign toxic metal ion of similar size and charge thus. Zn^{2+} in some metallo-enzyme is substituted by Cd^{2+} which leads to cadmium toxicity.

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Table 1: Toxic Metals

Elements	Sources	Effects and Significance
As	Mining by product, pesticides, chemical waste	Toxic possibility carcinogenic
Cd	Industrial discharge, mining waste, metal plating, water pieces	Replaces Ca biochemically, caused high blood pressure, kidney damage destruction of testicular tissue and RBCs, toxicity to aquatic biota.
Cr	Metal plating cooling tower water additive (chromates)	Essential trace element, Carcinogenic
Cu	Metal plating, industrial and domestic waste Mining, mineral leaching	Essential trace elements, not very toxic to animals, toxic to plants and algae at moderate levels.
Pb	Industry, mining, plumbing, coal, gasoline	Toxic anemia, kidney disease, nervous disorder wildlife destroyed.
Se	Natural geological sources, Sulphur, coal.	Essential at low levels but toxic at higher levels.

MAERIALS AND METHODS

Selection of sampling site

Water sources of Sagar city ($23^0$50'N and$78^0$43'E in map 1),all most all near around by Garages, automobile workshops, painting workshop rather they were from dug well, tube well, tap water, Hand pump water and lake water, water samples collected and evaporated up to 10 time decreased concentration. Among all samples some selected samples from above described sources were by spot test further analyzed by other parameters. 5 samples from different 5 corners of lake and 1 from the center of the lake, 7 sample from drinking water sources near around lake, 9 sample from Bhagwanganj area, 5 samples from Apsara Talkies area and 2 samples from Tilakganj area were selected by spot test for further more study.

The all water quality parameters have been performed regularly in every month for the duration of Jan 2009- Dec-2009 and July 2010 – June 2011 here only selected values of each perimeter were written. The need of calculating water quality parameters in this research work is to sport to prove presence of heavy metals or the increased water quality parameters supported that there may be chance and suitable environment for heavy metal contamination. The Determination of toxic metal concentrations has performed regularly in every month during above mentioned period from bottom layer of lake water. The study area of lake was divided into 5 parts.

S1 → near main Bus stand

S2 → near Duffrin Hospital

S3 → Chakraghat

S4 → Sanjay drive

S5 → Dhobighat

S6 → Center

The drinking water sources are indicated as below

B1 ……. B9 Bhagwanganj area's dug wells and Tube wells

T1 ……. T5 Tulsinagar area's dug wells and Tube wells

L1 ……. L6 Near around Lake Area's dug wells and Tube wells

TG1 ……. TG2 Tilakganj area's dug wells and Tube wells

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The Bhagwarganj and Tulsi Nagar and Tilakganj area were selected according to different-different reasons are as follows:

Bhagwanganj: - The area was located with large numbers of garages, servicing shops and painting denting workshops. The human population is also very high in that area.

Tulsi Nagar (Apsara Takij):- This area is also attached to Bhagwanganj have high population of humans with less hygienic habits, poor drainage and cleaning activities.

Near Around Lake: - Due to pollution in lake water the sources near surrounded lake have the possibility of pollution`

Tilakganj: - This area is also having many garages.

Water Sampling:

The all water samples were collected in previously rinsed with 8 M HNO_3 plastic bottles the pH of the water sample were measured within 4 hour of sample collections. Each sample was immediately filtered to separate suspended impurities also 8M HNO_3 (1-2 drops) used as preservative. The Lake water sample have collected from three layers upper, middle and bottom respectively, in different seasons during Jan 2009 to Dec. 2009 and July 2010 to Jun 2011.

Apart from this the water samples collected from different drinking water sources from Sagar town which include the water samples of dug wells, tap water samples and hand pumps and specially the dug wells and hand pumps, situated in the area where the density of the vehicles and garages is high and the soil is full of the waste coming out from the garages, battery repairing shops, also the hand pumps near lake where the possibility of contamination from lake water is suspected.

Trace metal analysis by AAS

The AAS method is used for the quantitative analysis of trace metals Like Pb, Cd, As, Se, Cr and Cu in water and Pb, Cd in soil at Chouksi Lab. Pvt. Indore (M.P.). The method of analysis is as per APHA 3113. All analysis have done by Atomic absorption spectrophotometer model no. AA6800 make SHINADZU.

As per their certificate of analysis the data have been shown in table No. 3-8 are given below. The samples from upper and middle layer of Lake Water contains most of time very low concentration of above toxic metals which are not possible to detect by quantitatively so there are only bottom layer Lake Water's results discussed here. The general analytical data for qualitative trace metal analysis by AAS given in table no. 2. And the table no.9 shows the concentration of Pb, Cd, As, Se, Cr and Cu in different drinking water sources of Sagar city.

Table 2: The analytical data for the determination of Pb, Cd, As, Se, Cr and Cu analysis by AAS is as follows:

Table 2: The analytical data for the determination of Pb, Cd, As, Se, Cr and Cu analysis by AAS

Element (metals)	Flame	Working rage (mg mL^{-1})	Wavelength of main resonance line λ(nm)
Pb	Air acetylene (lean fuel)	0.10-20	217.0
Cd	Air acetylene (lean fuel)	0.05-2	228.8
As	Air hydrogen (fuel rich)	0.01-50	193.7
Se	Air acetylene (lean fuel)	0.01-20	221.4
Cr	Air acetylene (lean fuel)	0.15-0.60	589.0
Cu	Air acetylene (lean fuel)	2-8	324.7

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Table 3: AAS analysis for the Concentration of Pb (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

Month / Site	Post mon-soon (Jan)	Pre monsoon of 2009				Mon-soon 2009	Mon-soon 2010	Post Mon-soon 2010-11(Oct)	Pre monsoon of			
		Apr	May	Jun	July				Mar	Apr	May	Jun
S1	0.09	1.41	1.3	2.1	0.12	0.02	0.02	0.10	1.99	1.43	1.93	2.3
S2	0.08	1.08	1.9	2.4	0.11	BDL	BDL	0.09	1.09	1.73	2.59	3.3
S3	0.09	0.17	2.0	2.3	0.09	0.02	0.02	0.08	1.39	0.19	2.0	2.9
S4	0.07	0.02	0.02	2.0	0.07	BDL	BDL	0.07	0.01	0.02	0.13	2.6
S5	0.08	0.02	0.01	2.1	0.05	BDL	BDL	0.09	BDL	0.01	0.18	2.1
S6	0.09	0.03	0.03	1.9	0.06	BDL	BDL	0.08	0.01	0.03	0.09	2.5

Table 4: AAS analysis for the Concentration of Cd (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

Month / Site	Post mon-soon (Jan)	Pre monsoon of 2009				Mon-soon 2009	Mon-soon 2010	Post Mon-soon 2010-11(Oct)	Pre monsoon of			
		Apr	May	Jun	July				Mar	Apr	May	Jun
S1	0.05	0.09	0.13	2.15	ND	ND	ND	ND	1.48	0.19	0.22	2.5
S2	0.04	0.06	0.21	1.9	ND	ND	ND	ND	0.48	0.09	1.09	2.1
S3	0.03	0.07	1.12	1.3	ND	ND	ND	ND	1.08	0.08	0.07	1.05
S4	0.05	0.01	1.0	0.08	ND	ND	ND	ND	0.01	0.03	0.06	0.09
S5	0.05	BDL	0.2	0.7	ND	ND	ND	ND	BDL	0.01	0.32	0.7
S6	0.05	0.04	0.09	1.4	ND	ND	ND	ND	0.03	0.05	0.08	1.04

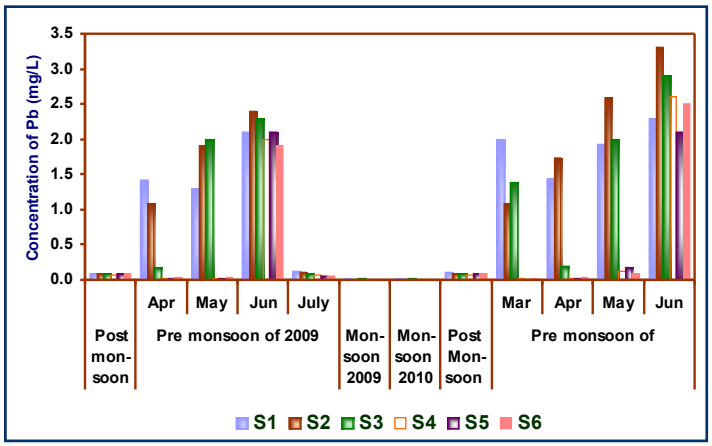

Fig. 1: AAS analysis for the Concentration of Pb (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

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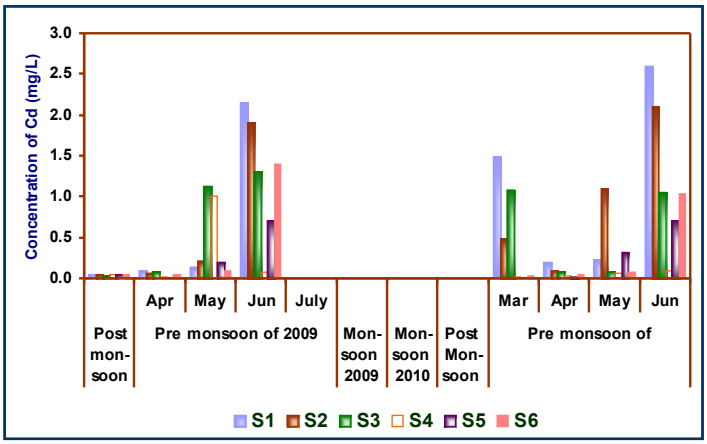

Fig. 2: AAS analysis for the Concentration of Cd (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

Table 5:AAS analysis for the Concentration of As (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

Month / Site	Post mon-soon (Jan)	Pre monsoon of 2009				Mon-soon 2009	Mon-soon 2010	Post Mon-soon 2010-11(Oct)	Pre monsoon of			
		Apr	May	Jun	July				Mar	Apr	May	Jun
S1	BDL	0.12	0.03	0.05	ND	ND	ND	ND	BDL	0.19	0.04	0.09
S2	BDL	0.26	0.14	0.19	ND	ND	ND	ND	BDL	0.39	0.19	0.22
S3	BDL	BDL	0.24	0.20	ND	ND	ND	ND	BDL	BDL	0.39	0.34
S4	BDL	BDL	0.27	0.27	ND	ND	ND	ND	BDL	BDL	0.30	0.32
S5	BDL	BDL	0.21	0.23	ND	ND	ND	ND	BDL	BDL	0.29	0.31
S6	BDL	BDL	0.19	0.17	ND	ND	ND	ND	BDL	BDL	0.21	0.26

Table 6: AAS analysis for the Concentration of Cr (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

Month / Site	Post mon-soon (Jan)	Pre monsoon of 2009				Mon-soon 2009	Mon-soon 2010	Post Mon-soon 2010-11 (Oct)	Pre monsoon of			
		Apr	May	Jun	July				Mar	Apr	May	Jun
S1	BDL	0.05	0.09	0.16	BDL	ND	ND	ND	0.05	0.09	0.18	0.20
S2	BDL	0.03	0.07	0.14	BDL	ND	ND	ND	0.03	0.08	0.13	0.22
S3	BDL	0.02	0.08	0.16	BDL	ND	ND	ND	0.02	0.11	0.17	0.21
S4	BDL	0.04	0.09	0.11	BDL	ND	ND	ND	0.01	0.11	0.19	0.28
S5	BDL	0.02	0.06	0.09	BDL	ND	ND	ND	0.06	0.12	0.18	0.20
S6	BDL	0.01	0.04	0.10	BDL	ND	ND	ND	0.05	0.11	0.19	0.22

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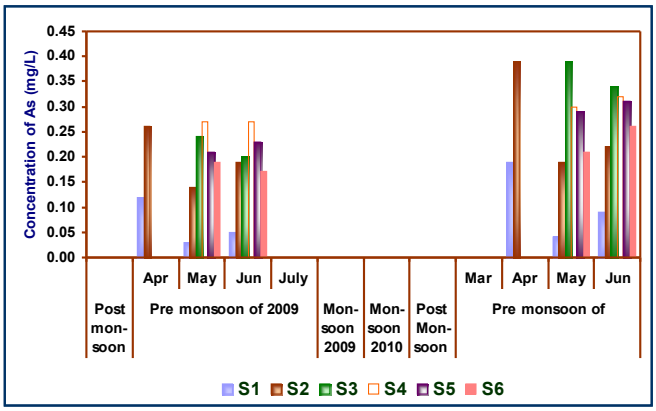

Fig. 3: AAS analysis for the Concentration of As (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

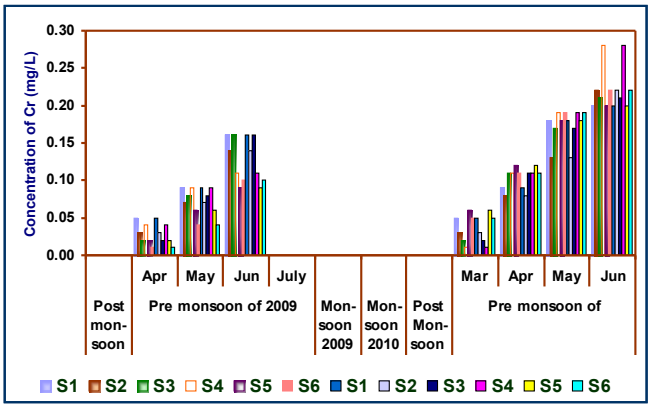

Fig. 4: AAS analysis for the Concentration of Cr (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

Table 7: AAS analysis for the Concentration of Se (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

Month / Site	Post monsoon (Jan)	Pre monsoon of 2009				Mon-soon 2009	Mon-soon 2010	Post Mon-soon 2010-11(Oct)	Pre monsoon of			
		Apr	May	Jun	July				Mar	Apr	May	Jun
S1	BDL	BDL	0.04	0.1	ND	ND	ND	ND	0.02	0.08	0.11	0.14
S2	BDL	BDL	0.06	0.1	ND	ND	ND	ND	0.03	0.06	0.10	0.14
S3	BDL	BDL	0.05	0.09	ND	ND	ND	ND	0.01	0.09	0.12	0.16
S4	BDL	BDL	0.02	0.08	ND	ND	ND	ND	0.03	0.07	0.11	0.15
S5	BDL	BDL	0.03	0.05	ND	ND	ND	ND	0.03	0.08	0.10	0.14
S6	BDL	BDL	0.02	0.07	ND	ND	ND	ND	0.02	0.09	0.12	0.15

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Table 8: AAS analysis for the Concentration of Cu (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

Month / Site	Post monsoon (Jan)	Pre monsoon of 2009				Mon-soon 2009	Mon-soon 2010	Post Mon-soon 2010-11 (Oct)	Pre monsoon of			
		Apr	May	Jun	July				Mar	Apr	May	Jun
S1	0.4	1.3	1.4	1.9	2.4	ND	ND	1.5	3.0	3.3	3.9	4.5
S2	0.3	1.2	1.5	1.8	2.2	ND	ND	1.8	2.9	3.0	3.6	4.4
S3	0.3	1.4	1.6	1.7	2.3	ND	ND	1.9	2.8	3.0	3.5	4.1
S4	0.4	1.2	1.5	1.8	2.3	ND	ND	1.5	2.5	2.9	3.3	4.0
S5	0.4	1.6	1.9	2.1	2.9	ND	ND	1.6	3.0	3.2	3.7	4.6
S6	0.5	1.5	1.6	1.9	2.8	ND	ND	1.7	2.8	3.1	3.6	4.4

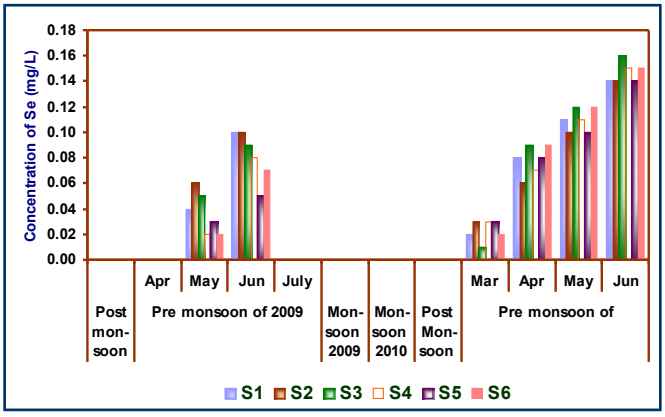

Fig. 5: AAS analysis for the Concentration of Se (mg/L) in Lake Water (during Jan 2009 to Dec 2009& July 2010 – June 2011)

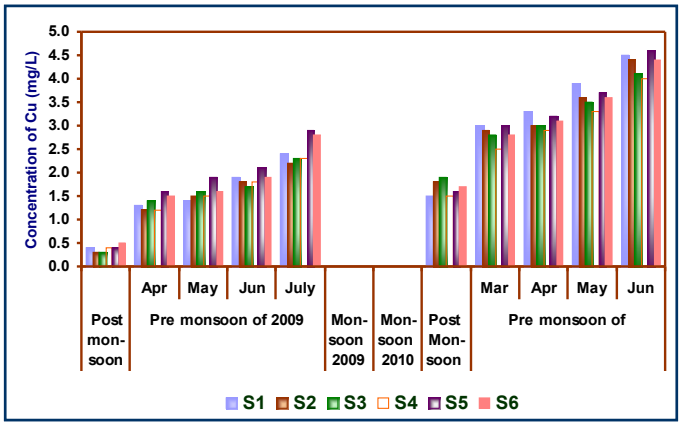

Fig. 6: AAS analysis for the Concentration of Cu (mg/L) in Lake Water (during Jan 2009

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Table 9:AAS analysis for the Concentration of six metals Pb, Cd, As, Se, Cr and Cu (mg/L) in drinking water sample of Bhagwanganj (1-9), near Apsara Talkies (10-14), around Lake (15-21), Tilakganj (22-23)

AAS analysais concentration (mg/L)												
Site	Pb		Cd		As		Se		Cr		Cu	
	Jun 2009	Jun 2011	Jun-2009	Jun-2011	Jun-2009	Jun-2011	Jun-2009	Jun-2011	Jun-2009	Jun-2011	Jun-2009	Jun-2011
B1	0.024	0.032	0.023	0.041	0.02	0.031	0.011	0.030	0.011	0.019	0.6	0.73
B2	0.023	0.031	0.022	0.042	0.01	0.030	0.012	0.032	0.012	0.021	0.5	0.75
B3	0.025	0.030	0.024	0.043	0.03	0.029	0.010	0.031	0.010	0.018	0.4	0.72
B4	0.024	0.033	0.025	0.040	0.02	0.032	0.011	0.029	0.013	0.017	0.7	0.74
B5	0.023	0.032	0.023	0.041	0.01	0.031	0.012	0.030	0.011	0.019	0.6	0.73
B6	0.025	0.031	0.022	0.042	0.03	0.030	0.010	0.032	0.012	0.021	0.5	0.75
B7	0.024	0.030	0.024	0.043	0.02	0.29	0.011	0.031	0.010	0.018	0.4	0.72
B8	0.023	0.033	0.025	0.040	0.01	0.032	0.012	0.029	0.013	0.017	0.7	0.74
B9	0.025	0.032	0.023	0.041	0.03	0.031	0.010	0.030	0.011	0.019	0.6	0.73
T10	0.021	0.039	0.021	0.043	0.019	0.033	0.021	0.031	0.019	0.021	0.5	0.78
T11	0.022	0.040	0.020	0.044	0.020	0.035	0.032	0.030	0.018	0.020	0.5	0.8
T12	0.020	0.038	0.022	0.042	0.021	0.034	0.013	0.029	0.020	0.022	0.7	0.7
T13	0.021	0.039	0.020	0.044	0.020	0.034	0.022	0.031	0.019	0.021	0.2	0.7
T14	0.022	0.040	0.022	0.042	0.021	0.035	0.032	0.030	0.018	0.020	0.6	0.8
L15	0.035	0.048	0.034	0.051	0.021	0.044	0.034	0.039	0.020	0.022	0.6	0.8
L16	0.033	0.049	0.033	0.052	0.020	0.045	0.033	0.040	0.022	0.031	0.7	0.9
L17	0.034	0.048	0.035	0.050	0.021	0.043	0.035	0.038	0.023	0.032	0.6	0.5
L18	0.035	0.050	0.034	0.051	0.021	0.044	0.034	0.039	0.021	0.030	0.8	0.9
L19	0.033	0.049	0.033	0.052	0.020	0.045	0.033	0.040	0.022	0.031	0.3	0.8
L20	0.034	0.048	0.035	0.050	0.021	0.043	0.035	0.038	0.023	0.032	0.5	0.6
L21	0.035	0.050	0.034	0.051	0.021	0.044	0.034	0.039	0.021	0.030	0.4	0.8
TG22	0.02	0.045	0.038	0.043	0.018	0.036	0.032	0.039	0.027	0.032	0.4	0.7
TG23	0.01	0.045	0.039	0.044	0.019	0.037	0.032	0.040	0.029	0.032	0.4	0.8

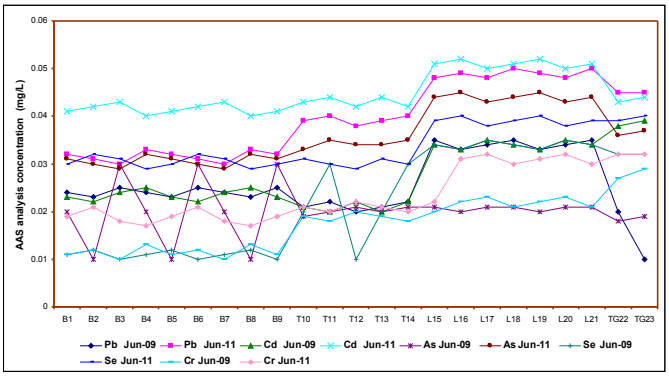

Fig. 7.1AAS analysis for the Concentration of Pb, Cd, As, Se, Cr (mg/L) in drinking water sample of Bhagwanganj (1-9), near Apsara Talkies (10-14), around Lake (15-21), Tilakganj (22-23) (during Jan 2009 to Dec 2009& July 2010 – June 2011)

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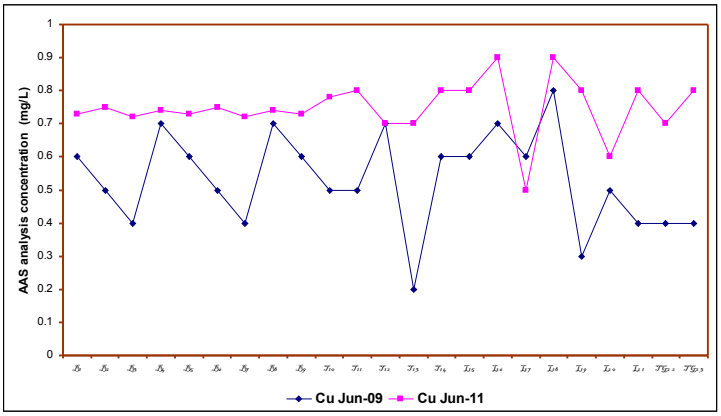

Fig. 7.2AAS analysis for the Concentration of Cu (mg/L) in drinking water sample of Bhagwanganj (1-9), near Apsara Talkies (10-14), around Lake (15-21), Tilakganj (22-23) (during Jan 2009 to Dec 2009& July 2010 – June 2011)

RESULTS AND DISCUSSION

The table no.2 shows the type of flame, working range (mg mL^{-1}) and wavelength of main resonance line λ(nm) for six metals like Pb, Cd, As, Se, Cr and Cu analysis by AAS. In the table 3-8 the concentration of all six toxic metals in different seasons found highest in summer season. Pb found 3.3 mg/L in Lake Water(S2) and 0.048mg/L (June 2011) in hand pump at L20 .The S1 site in Lake Water have also Cd 2.5mg/L and 0.021 in hand pump water. As concentration is 0.09mg/L in Lake Water and 0.044mg/L in hand pump water. Se and Cr have been found 0.14mg/L in Lake Water and 0.030 mg/L in hand pump water, 0.20mg/L in Lake Water and 0.019mg/L in hand pump water respectively. Cu concentrations have been found 4.5mg/L in Lake Water and 0.75mg/L in hand pump water. The highest concentration of toxic metals like Pb, Cd, As, Se, Cr and Cu have been found in Lake Water are 3.8mg/L at S2 site, 2.6mg/L at S1 site, 0.34mg/L at S3 site, 0.28mg/L at S3 site, 4.6mg/L at S5 site respectively. And in table 9 show the concentration of other different drinking water sources for above toxic metals. The concentrations have been found Pb 0.050mg/L at hand pump near Lake and Bus stand area, Cd 0.051mg/L at Dufrin Hospital and Bus stand area, As 0.045mg/L at near Lake and Bus stand area Cr 0.032mg/L Bus stand and Tilakganj area, Se 0.040mg/L at bus stand and Tilakganj area, Cu 0.9mg/L at Bus stand area.So the over all result is that the drinking water sources near lake and Tilakganj have been most polluted and not fit for drinking purpose.

The S1 site contains higher Pb concentration in summer season the S1 site has a Bus Stand due to this side has 24 hours, traffic so the Pb concentration is high, in monsoon season the water is extremely dilute. So the metals were absent. The terms BDL (below detection limits) shows that the metal is present but concentration is less than 0.01ppm similarly ND (not detected) shows there is no metal present in particular water sample. S2 site had higher Cd, and Pb due to heavy traffic on road in between lake and Duffrin hospital. Some hospital's patient washes their clothes in lake water. The S3 site also shows higher Pb, Se and Cd, the Indian ladies have paste cumcum (Tetra plumbium oxide) on their forehead these ladies takes holy bath at special festive seasons. The cum-cum contain PbO, so this the water contain Pb the S3 side is near to gold workshop area so this water contains Se because Se is used in the processing of Gold and Silver ornaments for washing and welding their joints. The S4, S5 site had the higher concentration of Se, Pb, Cd, Cr, due to use of washing detergent and waste from hospitals, and waste air gases through the road surrounded the Lake. In the S5 site the heavy metal deposition shows that the long time contact with polluting factors like traffic roads peoples who cropped aquatic vegetables, fisheries and all human activities including from all five sampling side etc. in the lake.

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CONCLUSION

The concentration of Cu, in overall all sampling sites have higher concentration than the permissible limit this shows various polluting factors were crossed the limit for mankind concern, so there is a need of rapid remediation program should be maintained.

The toxic heavy metal concentration found in higher than their permissible limits only in the month of June when water level became so deep and concentrated at near around Lake, Bhagwanganj, Apsara Talkies area which was near to Bhagwanganj, and Tilakganj, the Bhagwanganj and Tilakganj. These sampling sites are densely populated with garages automobile servicing shops, painting shops for car décor etc. so all water sources is not fit for human use [26].

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