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Spatial and temporal variation in arsenic in ground water samples along Budhi Gandak belt of Muzaffarpur district, Bihar, India

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The present study was undertaken with the objective to study the seasonal variation in arsenic level of groundwater samples along Budhi Gandak belt of Muzaffarpur district in Bihar, India. Samples were collected on the monthly basis from 2011 to 2013 and the variation in the arsenic content was observed and monitored upto 36 months at eight different sites. The results of the present investigation reveal that there is a temporal fluctuation in the arsenic level in the ground water; the pattern, although not simplistic, shows a higher level in the winter season.

Keyword: Groundwater quality, spatial & temporal variation, arsenic, Budhi Gandak belt, Muzaffarpur.

1. Introduction

Arsenic, a semi-metal member of the group 15 elements, occurs naturally in the earth and in the seas. It is odourless and tasteless. Arsenic occurs in the earth's crust–rock, soil, all natural sources of exposure and also can be traced to deep water brines used to produce oil and natural gas. Consumption of food and water are the major sources of arsenic intake. People may also be exposed from industrial sources, as arsenic is used in semiconductor manufacturing, petroleum refining, wood preservatives, animal feed additives, and herbicides. Arsenic combines with other elements to form inorganic and organic arsenicals. In general, inorganic derivatives are regarded as more toxic than the organic forms. While food contains both inorganic and organic arsenicals, primarily inorganic forms are present in water.

Arsenic exists in several different oxidation states: +V (arsenate), +III (arsenite), 0 (arsenic) and –III (arsine) [1, 2]. In typical ground water environments, arsenic is present in As (III) and As (V) states depending on the amount of oxygen available in ground water. In more shallow aquifers with higher levels of oxygen, arsenic usually exists as arsenate, As (V). In deeper, anaerobic ground waters, arsenic usually occurs as arsenite, As (III). As (III) is generally more mobile in water than As (V), and has higher toxicity [3]. The soluble arsenite species are H_3AsO_3, $H_2AsO_3^-$, $HAsO_3^{2-}$ and AsO_3^{3-}. The soluble arsenate species are H_3AsO_4, $H_2AsO_4^-$, $HAsO_4^{2-}$ and AsO_4^{3-}.

Due to the withdrawal of excessive amounts of groundwater, problems of increased iron, fluoride and arsenic contamination have been reported in different parts of India [4, 5]. A recent study on cancer risks from arsenic in drinking water indicates that it could cause liver, lung, kidney and bladder cancers besides skin cancer [6-7]. In addition, it has been reported to affect the vascular system in humans and has been associated with the development of diabetes.

The observable symptoms of arsenic poisoning are: thickening and discoloration of the skin, stomach pain, nausea, vomiting, diarrhea, numbness in hands and feet, partial paralysis, and blindness. It is widely thought that naturally occurring arsenic dissolves out of certain rock formations when ground water levels drop significantly. Surface arsenic-related pollutants enter the ground water system by gradually moving with the flow of ground water from rains, melting of snow, etc. Both WHO and US EPA have

recommended the maximum permissible limit of arsenic in drinking water as 10 ppb.
The table below shows the lifetime risks of dying of cancer from arsenic in tap water, based on the National Academy of Sciences' 1999 risk estimates.

Arsenic Level in Tap Water (in parts per billion, or ppb)	Approximate Total Cancer Risk (assuming 2 liters consumed/day)
0.5 ppb	1 in 10,000
1 ppb	1 in 5,000
3 ppb	1 in 1,667
4 ppb	1 in 1,250
5 ppb	1 in 1,000
10 ppb	1 in 500
20 ppb	1 in 250
25 ppb	1 in 200
50 ppb	1 in 100

We have, in the present work, studied arsenic contamination in water samples from bored tube wells at different stations along the Budhi Gandak belt in Muzaffarpur district of Bihar state in all the 36 months from 2011 to 2013. The purpose of this study was to ascertain the temporal variation [8-12] in the arsenic content and the study for three consecutive years could conclusively give a concrete pattern of such variations.

2. Material and Methods

Water samples of bored tube wells were collected from 8 different sites of different regions along the Budhi Gandak belt in Muzaffarpur district of Bihar state during different months of 2011 to 2013. The samples were collected in precleaned polythene bottles with necessary precautions (APHA 2006) [13]. Arsenic was estimated by using UV-Visible spectrophotometric standard methods [13-15]. Table 1 gives the GPS locations of the sampling sites.

Table 1: GPS locations of sampling sites

Sampling sites	Sample no.	GPS locations
Balughat, Raj Narayan Singh College	S_1	$26^0$08.057' N $85^0$23.740' E
Lakdi Dhahi, Sanjeev Kumar's residence	S_2	$26^0$07.910' N $85^0$24.024' E
Lakdi Dhai, Vijay Ram's residence	S_3	$26^0$07.898' N $85^0$24.160' E
Chandwara Bagnighat, Surendra Mahto's residence	S_4	$26^0$07.806' N $85^0$24.338' E
Chhid Bhagwatipur, Mai Asthan	S_5	$26^0$07.894' N $85^0$24.691' N
Kanhauli Shaadullahpur, Md. Suleman's residence	S_6	$26^0$07.483' N $85^0$24.617' E
Kanhauli Bishnudattapur, Mohan Sahni Mohalla	S_7	$26^0$07.537' N $85^0$25.055' E
Kanhauli, Harkut Chaudhary Mohalla	S_8	$26^0$07.436' N $85^0$25.608' E

2.1 Principles

Arsenic was determined by the silver diethyldithiocarbamate method. Arsenic in the reaction solution was converted to arsine, which was evolved and then complexed with silver diethyldithiocarbamate. The intensity of the colour of the complex was determined with a spectrophotometer. Arsenic concentration was ascertained by reference to a calibration curve prepared with the aid of standard arsenic solutions.

Table 2: Concentration of Arsenic (in ppb) in different months of the year 2011

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
S_1	58	62	70	45	40	28	25	38	50	35	47	55
S_2	55	62	65	37	30	28	15	25	45	28	40	55
S_3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
S_4	65	70	80	55	50	40	37	42	60	45	58	62
S_5	118	120	125	105	102	92	90	95	110	100	107	115
S_6	38	40	45	27	25	15	10	17	32	20	30	35
S_7	52	55	60	35	32	20	15	25	45	28	42	50
S_8	Nil	10	15	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Table 3: Concentration of Arsenic (in ppb) in different months of the year 2012

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
S_1	55	60	72	47	45	30	25	32	50	37	49	53
S_2	53	60	70	35	32	25	20	28	42	30	37	45
S_3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
S_4	75	80	90	50	48	37	35	40	62	43	55	70
S_5	110	115	120	98	95	88	85	90	107	92	100	108
S_6	40	45	50	25	22	13	12	15	30	18	28	35
S_7	47	50	70	37	35	25	20	27	40	30	40	45
S_8	20	Nil	65	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Table 4: Concentration of Arsenic (in ppb) in different months of the year 2013

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
S_1	60	65	67	48	45	30	27	35	53	40	50	57
S_2	50	60	70	32	28	17	15	20	40	25	35	47
S_3	Nil	10	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
S_4	72	75	85	48	45	35	30	35	60	40	50	45
S_5	115	118	122	100	96	85	80	88	105	90	102	110
S_6	45	50	55	30	25	17	15	20	40	22	35	42
S_7	55	62	65	32	30	17	10	20	45	27	37	48
S_8	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

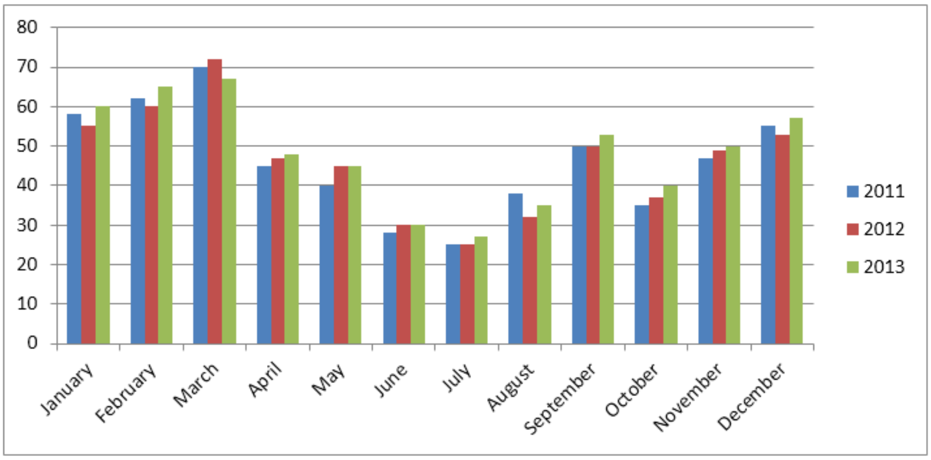

Fig 1: Graphical variation in level of arsenic (in ppb) in ground water sample, S_1 during the years 2011-2013

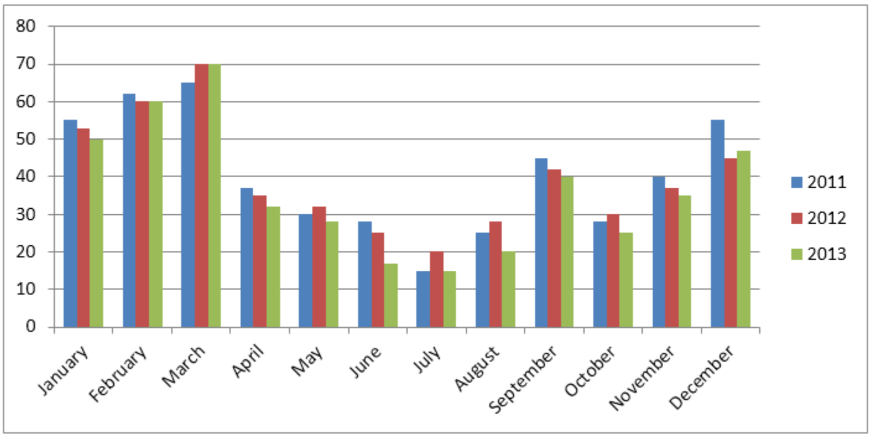

Fig 2: Graphical variation in level of arsenic (in ppb) in ground water sample, S_2 during the years 2011-2013

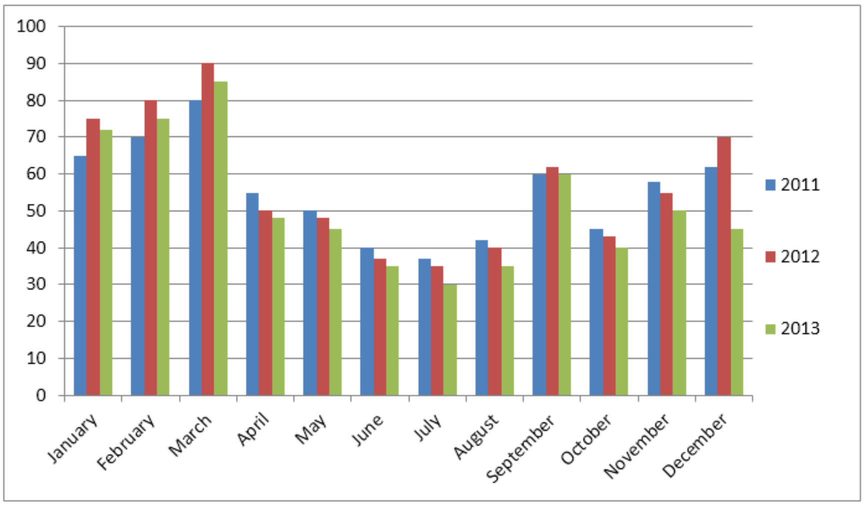

Fig 3: Graphical variation in level of arsenic (in ppb) in ground water sample, S_4 during the years 2011-2013

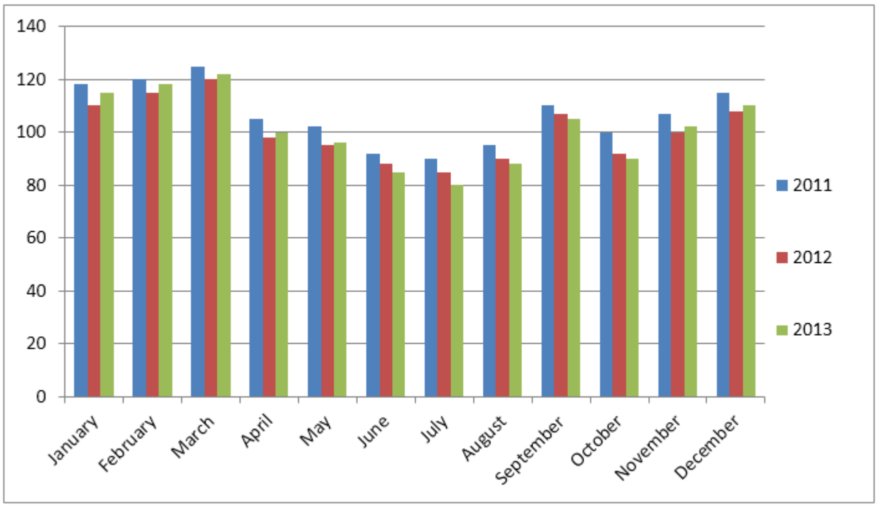

Fig 4: Graphical variation in level of arsenic (in ppb) in ground water sample, S_5 during the years 2011-2013

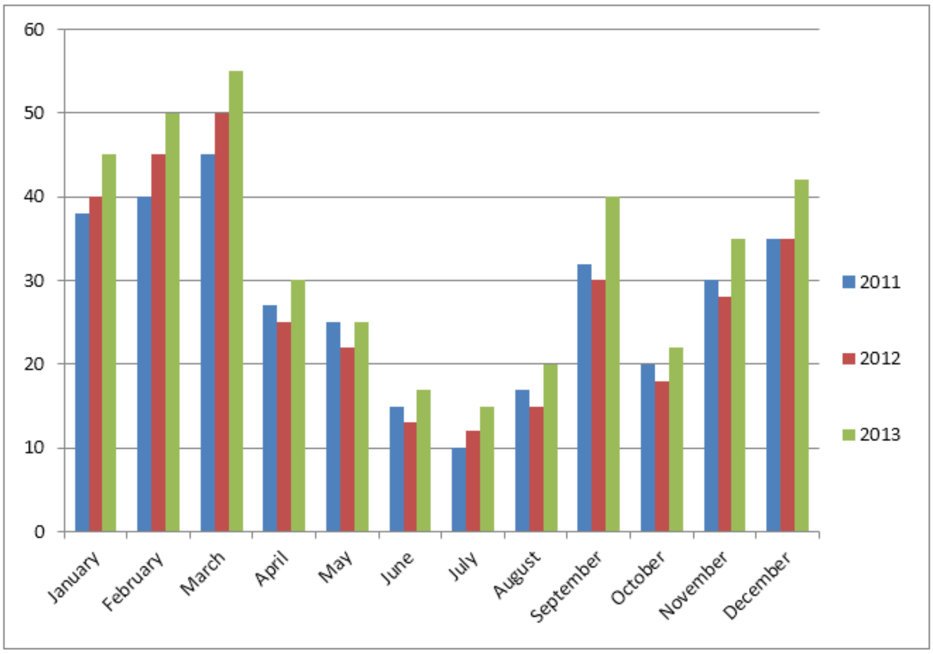

Fig 5: Graphical variation in level of arsenic (in ppb) in ground water sample, S_6 during the years 2011-2013.

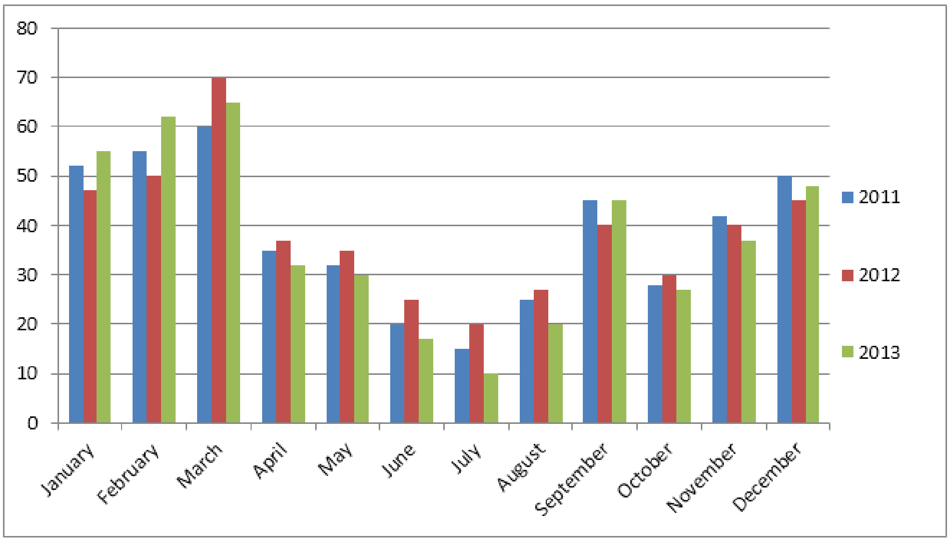

Fig 6: Graphical variation in level of arsenic (in ppb) in ground water sample, S_7 during the years 2011-2013

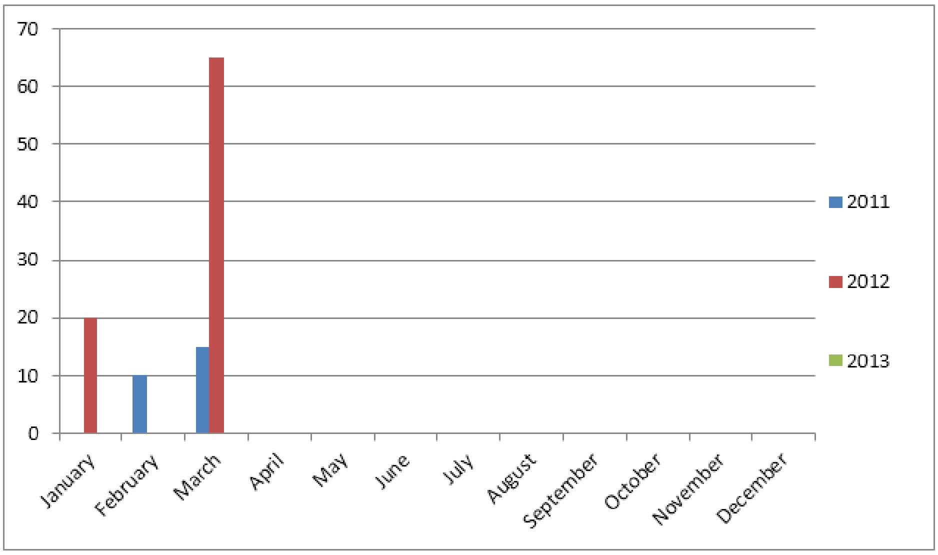

Fig 7: Graphical variation in level of arsenic (in ppb) in ground water sample, S_8 during the years 2011-2013

- Graphical variation of level of arsenic has not been shown for sample no. S_3 because arsenic was not detected in this sample during any of the 36 months studied except one in which it was found to be only 10 ppb.

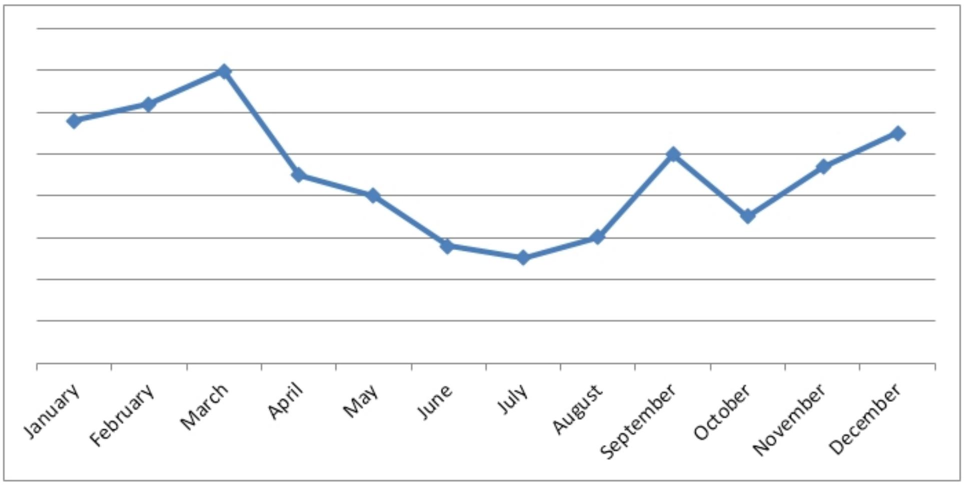

Fig 8: A generalized plot depicting As levels in ground water samples during different months of a year.

3. Results and Discussion

Although no discrete temporal pattern of arsenic level in the ground water was observed in any of the samples as certain variations were observed in different years for the same sample and from sample to sample, some significant conclusions can still be drawn. Like, there was, in general, a higher level of As in the winter season as compared to those in the summer and rainy seasons. However, in the winter season there was an increasing trend from the month of November onwards reaching a maximum in the month of March. A sudden plunge in the arsenic level was observed from April onwards reaching lowest level in the month of July and then suddenly rising in the month of September taking a sudden plunge in the month of October and then again rising from November onwards.

The reasoning for the aforesaid pattern of arsenic levels in the different months of a year needs further in depth geochemical studies.

4. Reference

1. Shen-Long TC, Singh S, Chen W. Arsenic metabolism by microbes in nature and the impact on arsenic remediation. Current Opinion in Biotechnology 2009; 20:659-667.
2. Mohan D, Charles U, Pittman Jr. Arsenic removal from water/wastewater using adsorbents—A critical review. Journal of Hazardous Materials 2007; 142:1-53.
3. Mumtazuddin S, Azad AK. Removal of Arsenic Using Mango, Java Plum and Neem Tree Barks, IJAPBC 2012; 1(3):372-376.
4. Singh AK. Arsenic contamination in groundwater of North Eastern India. In Proceedings of 11th National Symposium on Hydrology with Focal Theme on Water Quality, National Institute of Hydrology, Roorkee, 2004, 255-262.
5. Bhattacharya P, Mukherjee AB. Management of arsenic contaminated groundwater in the Bengal Delta Plain. In conference on Management of Water Resources (eds M. Chatterji, S. Arlosoroff and G. Guha), Ashgate Publishing, UK, 2002, 308-348.
6. Nickson RT, McArthur JM, Burgess WG, Ahmed KM, Ravenscroft P, Rahaman M *et al*. Arsenic poisoning of Bangladesh groundwater Nature 1998; 338-395.
7. Singh AK. Approaches for removal of arsenic from groundwater of northeastern India. Current Science 2007; 92(11):1506-1515.
8. Malaviya P, Rathore PS. Seasonal variations in different physico-chemical parameters of the effluents of century pulp and paper mill, Lal Kuan, Uttarakhand. Journal of Environmental Biology 2007; 28(2):219-224.
9. Mustapha A, Driss B, Mohamed B. Seasonal variations in physico-chemical parameters of water body Amghass II Province Irfane Morocco, Universal Journal of Environmental Research and Technology 2013; 3(6):660-666.
10. Rai AK, Diba F, Paul B. A study on the seasonal variations of different physic-chemical water quality parameters of Indrapuri Dam Rohtas District Bihar. International Journal of Environmental Sciences 2013; 2(3):125-129.
11. Satpathy KK, Mohanty AK, Natesan U, Prasad MVR. Sarkar SK. Seasonal variation in physic-chemical properties of coastal waters of Kalpakkam, east coast of India with special emphasis on nutrients. Environ Monit Assess 2010; 164:153-171.
12. Jagadeshappa KC, Kumara V, Raghvendra Gowda HT, Pramod AF. Seasonal variation in physico-chemical characteristics of water in two wetlands of Tiptur Taluk, Karnataka. Recent Research in Science and Technology 2011; 3(11):96-99.
13. APHA, Standard Methods of Examination of Water and Wastewater, Edn 19, American Public Health Association, Washington DC, 1996.
14. De AK. Environmental Chemistry. Edn 7, New Age International Publishers, N. Delhi, 2010.
15. EPA, Quality Criteria for Water, Environmental Protection Agency, Washington DC, USA, 1976.