Estimation of groundwater inflow to Dal Lake using isotopic mass balance approach

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Abstract

Estimation of groundwater-lake water interaction is essential for both water quantity and water quality management decisions. Dal Lake, a famous urban fresh water lake, plays a fundamental role in the social, cultural and economic dynamics of the Srinagar city. Isotopic composition of ä^{18}O and ä^{2}H in groundwater showed similar isotopic signature as were observed in precipitation. However, lake water isotopic composition (ä^{18}O = -8.2 to -6.8) in different basins showed more deviation from the global meteoric water line (GMWL) indicating the evaporation in lake water. The isotopic mass balance (IMB) suggested that groundwater contributes a significant proportion (19-34%) to the Dal Lake.

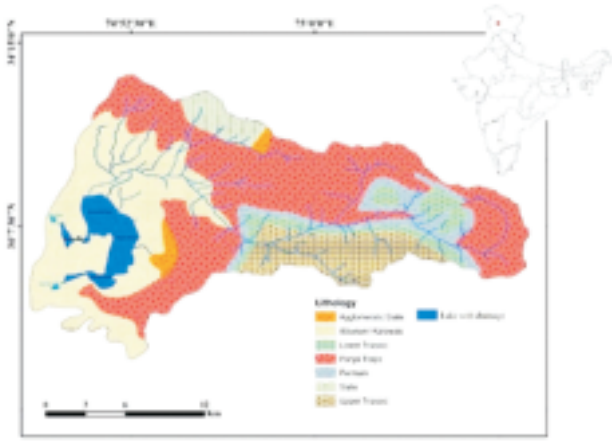
Keywords: Dal Lake, hydrologic budget, stable isotopes, isotopic mass balance.

1. Introduction

Groundwater is hydraulically connected to lakes and an understanding of this interaction is fundamental to effective water resource management [1]. Interaction between the two influences the characteristics of lake water, including the stability of water level and water quality. These interactions are complex both in time and space, and are not only influenced by climate, landform, geology, and biotic factors but also by fabricated human activities. The objectives of this paper/work are to characterize the isotopic signatures and their variations in lake water and surrounding groundwater in order to constrain the sources of the lake water using isotope mass balance.Dal, second largest lake in the north-east township of Srinagar city (Figure 1). The lake has a total area of 12 km^2 [2]. The average annual inflow and outflow have been estimated as 291×10^5 and 275×10^5 m^3 respectively.

2. Material and methods

Water samples were collected in 125 ml HDPE bottles from precipitation (n=27), lake water (n=18) and groundwater (n=32) for ä18O and ä2H analysis. Precipitation samples were collected in homemade precipitation collectors, fitted at many selected sites across the study area. Stable water isotope ratios hydrogen (ä2H) and oxygen (ä18O) were analyzed at Physical Research Laboratory (PRL), Ahmedabad, by Dual Inlet Isotope Ratio Mass Spectrometer through gas equilibration method.



3. Results and discussion

The isotopic composition of lake water ranged from -8.9 to -4□ for □18O and from -52 to -30□ for □2H. Groundwater □18O ranged from -8.6 to -4.7□, and □2H ranged from -29.9 to -53.7□ with an average of -45.5□. □18O versus □2H plot (Figure 2) of surface water, lake water and groundwater from the Dal catchment clearly shows that the samples from groundwater and streams have similar isotopic values than the lake water. Groundwater and stream water samples were characterized by lighter isotopes, with higher slope (6.8 and 8.5) and intercept (8 and 21) than the local meteoric water line (LMWL). On the other hand the isotopic values of lake water were relatively enriched in the heavy isotopes, with lower slope (3.9) and intercept (15) than LMWL. This suggested that the isotopic composition of lake water is modified by evaporation, while as the isotopic composition of the stream and groundwater have retained their original signature.

The degree of evaporation is also reflected in the isotopic composition of different basins of the lake: Hazratbal basin (□18O = -8.2), Boddal basin (□18O = -6.8), Nigeen basin (□18O = -6.9) and Gagribal basin (□18O = -5.3). The lower isotopic values in Hazratbal baisn reflects the dominant influence of the main inflow stream, whereas the higher isotopic value in Gagribal basin is attributed to the evaporation (the last basin with outflow). Samples collected to the west and south east side of the lake (Boddal and Gagribal basins) plot further away from the global meteoric water line (GMWL) suggesting

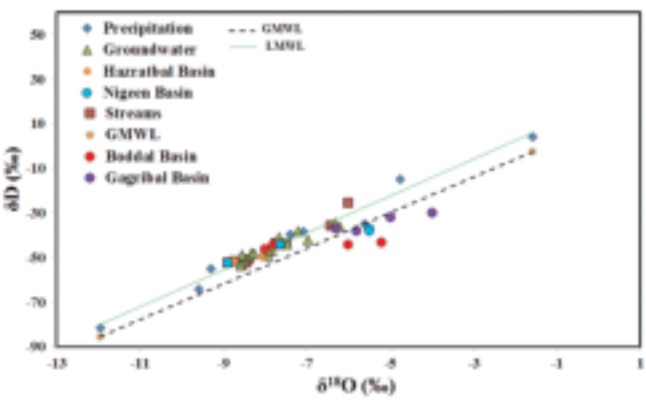


Figure 2. Isotopic signatures in precipitation, lake water, streams and groundwater

The most depleted values were during spring in Nigeen basin and the most isotopically enriched values were observed during the autumn months in Gagribal basin. During spring season the lake water is heavily influenced by snow melt, so lake water samples plot very closely to the meteoric water line. When lake water is exposed to sunlight and heat during the summer and autumn, lighter isotopes (ä16O and äH) are evaporated preferentially. With fewer light isotopes, the remaining lake water is enriched in ä18O and ä2H, causing isotopic composition of that water to show more positive ä18O and ä2H values. Throughout the study, isotopic mass balance (IMB) results showed direct relationship between groundwater and lake water. It was found that groundwater is entering into the lake at all locations and there is no contribution of lake water into the groundwater recharge It was found that groundwater contributes 19 % to 34% to the lake (Figure 3). Maximum contribution was found in winter season and lower contribution in autumn season. Spring and summer contribute 24.7% and 31%. The total volume of water stored in the lake varied from 79.1×106 m3 to 56.8×106 m3, highest was recorded in the summer months and lowest in winter months. Spatially, Hazratbal basin exhibits more volume than Boddal, Gagribal and Nigeen basins. In Hazratbal basin it ranged from (28×106 to 39×106 m3) whereas in Boddal, Gagribal and Nigeen basins, the total volume of water varied from (15×106 to 20.8×106 m3), (10.8×106 to 15×106 m3) and (2.7×106 to 3.8×106 m3), respectively. Maximum lake volume and water was found in summer months, particularly in June and lower in winter months, especially in January.

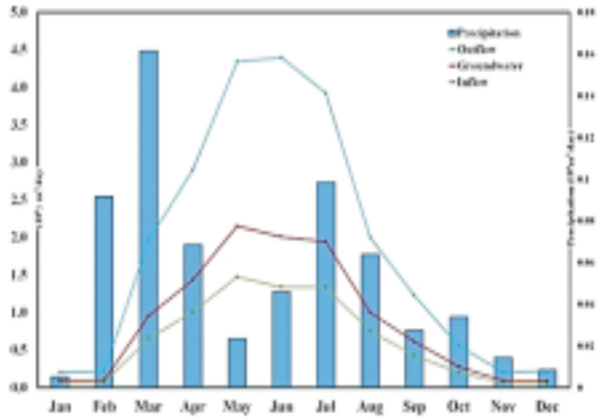


Figure 3.Monthly fluxes of various water balance components in Dal Lake.

4. Conclusions

The isotopic composition result indicates that groundwater is entering the lake basin at all locations. It contributes 19% to 34% to the lake water. Maximum contribution was found in winter season and lower in autumn season.

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Deterioration of river water quality due to excessive use of chemical fertilizer A case study at Gin River, Sri Lanka

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Abstract
The Primary aim of a catchment safety plan is to reduce risks within the catchment to protect the quality of drinking water sources at the intake point. Even effective arrangements for quality assurance and quality management have been established, unexpected deterioration in raw water can be affected to treated drinking water quality. Important steps of catchment safety plan include risk assessment, risk minimizing and monitoring effectiveness. In this study, correlation matrix was developed between water quality and land use patterns to assess the risk of water quality due to suspected improper human activities. Social survey was carried out in a pilot tributary area based on the primary observations of water quality parameters. The findings of this research would be the base for developing a proper catchment safety plan.

Keywords: Water safety plan; Land use; Chemical fertilizer usage

1. Introduction

"Supplying good and safe drinking water is a key issue in public health protection policies"(Viera&Pinho, 2014). However, a substantial majority of people live in Asia still lack access to safe water supplies (Saini, Khitoliya& Kumar 2014). Protection of raw water quality is one of paramount interest for ensuring the safe water in drinking water supply system. Thus potential pollution sources should be clearly identified and monitored. Understanding the nature of sources of contamination and how these may enter the water supply is critical for assuring water safety. In this regard, catchment management is more important to identify preventive measures at the point of absorption and to reduce cost and barriers in water safety plan compared to the treatment process. The aim of this study is to investigate possible correlation between water quality parameters and land use classes in which suspected improper artificial fertilizer utilizations are practiced.

2. Material and methods

Water quality risk assessment was done by characterizing catchment under geophysical, hydrological, water quality and sociological aspects. Seasonal variation was analyzed by considering a typical wet season (August, 2016) and compared with Central Environmental Authority (CEA) standards for drinking water with simple treatment (CEA 2011 cited in Nagasinghe 2014). Study area and the geographical locations of sampling points are shown in Figure 1.

The land use patterns were identified by developing sub catchments related to each sampling point based on 2013 land use map with 1:10,000

Figure 1. Sampling points and tributary catchments

Based on land use area and water quality data, a correlation matrix was developed using Pearson product - moment correlation coefficient ('CORREL' function in Microsoft Excel 2015). Social survey was conducted at Thalangalu tributary catchment based on the initial water quality data. Comparison was done between Thalangalu tributary catchment and the other 5 tributary catchments, with their water quality parameters to identify the entire Gin river catchment behavior. A trend analysis has also been done between Thalangalu tributary and other tributaries for different land use types.

3. Results and discussion

Water quality parameters measured at Gin river basin during the dry period shown in Figure 2. The highest COD has been detected at point G, at the outlet of Talangalu tributary. Therefore, the social survey was conducted within the Talangalu tributary. The social survey reveals that the farmers use chemical fertilizers more than the recommended amount (Table 1).

Figure 2. COD variation along the main stream

A correlation matrix between land use classes and water quality parameters was developed for the Thalangalu tributary (Figure 4).

Table 1: Usage of chemical fertilizer

Crop Type	Fertilizer Type	Ingredients	Usage	
			Average	Recommended
Paddy	MOP	P – 50% Cl – 46%	60 Kg/acre	42 Kg/acre
	TSP	P – 45% Ca – 15%	35 Kg/acre	20 Kg/acre
	Urea	N – 46%	80 Kg/acre	50 Kg/acre
Tea	T200	N – 5.1% P – 15% K – 60%	40 g/plant	32g/plant
	T750	N – 10% P – 15% K – 60%	100 g/plant	100g/plant
	T709	N – 27%	40 g/plant	25g/plant
	VPLC	N – 29% P – 32.5% K – 60%	275 g/plant	275/plant

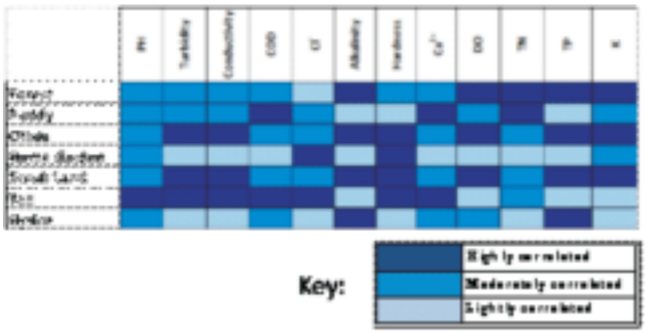
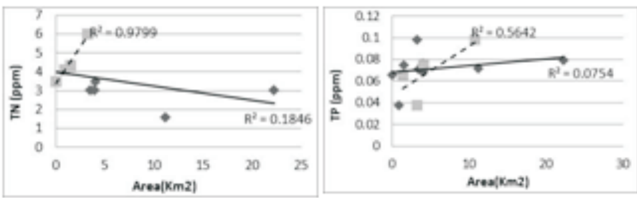
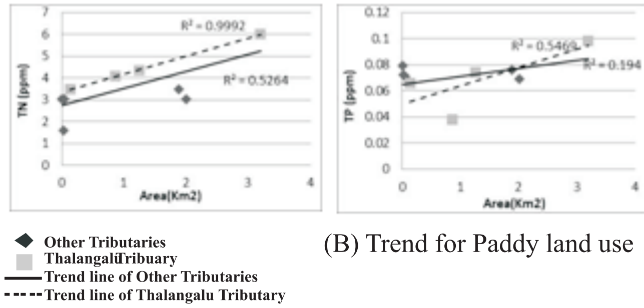


Figure 3. Correlation matrix

The high COD value observed at the outlet of Talangalu (Figure 2) is due to high concentration of chemical fertilizer used at the tributary catchment (endorsed by social survey, Table 1).



(a) Trend for Forest land use



(B) Trend for Paddy land use

Figure 4. Correlation of land use and water quality for Forest and Paddy

The general correlation matrix (Figure 3) developed for the pilot area also suggested that COD and TN concentrations are considerably high in paddy and tea cultivation compared to other land use classes.Figure 4(a) illustrates the trend of selected water quality parameters (TN and TP). They are having identical and comparable trends in other tributaries for paddy cultivation land use. However, no clear trend can be seen for forest land use.

4. Conclusions

Water quality is correlated with land use patterns to develop the correlation matrix. Colour, Turbidity, pH and DO can be identified as most sensitive parameters for land use changes. TN, TP and COD are proportionate with cultivated land areas including paddy, tea and home gardens. According to the social survey, farmers use over dosage of agro chemical for the cultivations compared with the recommended quantities. Controlling change of land use and usage of agro chemical seems as a viable solution in order to manage drinking water quality.

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Water/Wastewater Treatment
and
Reuse Technologies
[SESSION B2]
PROCEEDING

Conflict Resolution of Enhanced Biological Phosphate Removal and Sludge Reduction in Oxic-Settling-Anaerobic (OSA) SBR

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Abstract
The emphasis on simultaneous removal of organics, nitrogen, and phosphorus along with in-place sludge reduction creates unique rather a conflicting situation. Sludge reduction requires high SRT, while enhanced phosphorus assimilative uptake demands low SRT. The assessment about the feasibility of OSA to achieve EBPR and sludge together was the virgin aspect of research on in-place sludge reduction by virtue of settled MLSS recirculationat different ratios to side stream anaerobic under the influence of average and lowest Carbon/Phosphorus (C/P) ratio of 50 and 15 respectively. Sludge reduction from 3% to 51% was observed on average basis by maintaining sludge recycle from 3.78 9.78 (average was 4.4 8.2) gVSSrecycled/gVSS present in the reactor. The phosphorus enrichment was 0.04690.135 mgTP/mgVSS resulting in 1.765.04 fold increase from stoichiometric content.
Keywords: Oxic-settling-anaerobic process; Sludge reduction; EBPR.

1. Introduction

Oxic-settling-anaerobic (OSA) process has well established the fact that anaerobic followed by aerobic in a cyclic order reduces the sludge [1-3].

Eq. 1 shows settled sludge recirculation to anaerobic tank out of total sludge in aeration tank, mgVSS/mgVSS

$$\text{Sludge recl ratio,} Rs = \left(\frac{Qrs\ Xs}{VX}\right)\left(\frac{Vn}{QRS}\right) = \frac{Vn\ Xs}{Vn} \qquad (1.0)$$

The EBPR in SBR with OSA depends on mass of VSS fermented in anaerobic reactor and the HRT or SRT of the VSS in the reactor as the fermentation of active sludge depends on these two main factors apart from many others. The key to EBPR is growth of PAOs which are normally present in mixed culture. Since, phosphate can only be taken by microbes in ortho form therefore anaerobic treatment is essential for it;moreover, conversion of substrate to VFA is also essential for storage of PHA products.

2. Materials and methods

Present study aimed at simultaneous EBPR and sludge reduction by coupling OSA by virtue of side stream anaerobic digestion of sequencing batch reactor sludge at different MLSS recirculation ratios of 0.25, 0.5, 0.75 and 1.0 L/cycle for 0.5 h/cycle after end of decantation resulted in 1, 2, 3 and 4 L/d settled sludge to anaerobic tank as shown in Fig. 1.0 below.

The C/N ratio and rbCOD/sbCOD ratios were kept intact at 7.5 and 0.25 respectively. The MLSS recirculation ratio (Qr/Q) during aeration was maintained at the ratio of 4 obtained earlier. The Carbon/Phosphorus (C/P) was maintained at average level of 50 in the first four stages and15 at 0.5 L/cycle in the last stage-5.

Figure 1. Scheme of sludge recirculation during OSA.

3. Results and discussion

***EBPR in SBR with OSA*:** The phosphate removal during the study is plotted in Fig.2.0 shows temporal variations in TP uptake in relation to sludge recirculation.

The phosphorus enrichment under different stages of operation was 0.0469   0.135 mgTP/mgVSS (4.7   13.5% phosphorus in the sludge) as against stoichiometric value of 0.0267 mgTP/mgVSS resulting in 1.76   5.04 fold increase in phosphorous content.

Figure2. Temporal variation in TP uptake with reference to C/P ratio and Qrs

The maximum uptake was obtained at less than 6.41 gVSS/gVSS recirculation ratio corresponding to 2 L/d sludge flow (Qrs)to anaerobic tank. Any further increase would have caused more leaching of TP than its uptake. However, when Ortho-P was more in the influent 14.39 mg/L in stage-5 as against 6.33 mg/L in stage-2, the corresponding increase in Ortho-P was from 4.27 to 7.16 mg/L in Stage-2 and 5 respectively.

Excess Sludge Reduction in SBR with OSA: The stoichiometric yield was calculated as given in Eq. (2.0) [4]and compared to maximum yield Ym and observed yield coefficients (Yobs)in order to evaluate sludge reduction potential as plotted in Fig. 3.0.

$$Y_t = \frac{0.212(1+0.030\theta x)}{(1+0.150x)} + \frac{0.1341+0.010\theta x)}{(1+0.0150\theta x)} + \frac{1.129(1+0.022\theta x)}{(2.5(1+0.110x)+0.14(1+0.022\,\theta x)}\left(\frac{C}{N}\right) \quad 2.0$$

Steady decline in observed growth rates from 0.26 (±0.024)to 0.13(±0.016) both gross and active with sludge recirculation rate and ratio of 3.78   9.78 gVSS recyl/gVSS presentwere observed, which amounted to 3% to 51% reduction in biomass yield.

Reasons of Sludge Reduction: The anaerobic followed by aerobic in a cyclic order reduces the sludge through promotion of catabolism and demotion of anabolism by uncoupling the two reactions, howeverwhen exposed to anaerobic conditions under severe food limiting condition microbes consume their conserved ATP which restrict their growth. The energy obtained and captured in the form of ATP during biological oxidation is used by the microbial cells for their maintenance followed by synthesis [1-3]. SOUR was increased during feasting and decreased during fasting (but with much less magnitude) with increased sludge recirculation to anaerobic reactor. The difference in SOUR values during anaerobic fasting and the gradient with respect to SOUR difference under no anaerobic stress resulted from high substrate oxidation during aeration may be induced by increased energy requirement stimulated by the prolonged fasting in anaerobic reactor [4].Chen et al. (2003) [2] cited low ORP as the sole reason of sludge reduction during the process of sludge fasting/feasting.

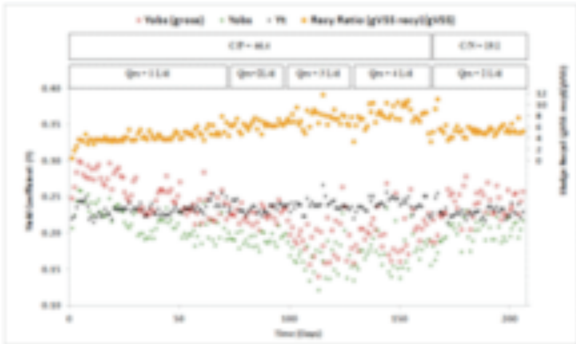

Figure3. Temporal variations in observed yield coefficient for varying sludge recycle rate and ratio to anaerobic reactor.

4. Conclusions

- Successful sludge reduction from 3% to 51% was observed on average basis by maintaining sludge recycle from 3.78   9.78 gVSS recyl/gVSS present.However, the process may not be continuing as further sludge reduction would cause overloading in terms of f/m ratios and less bCOD reduction
- The TP uptake was 0.0469   0.135 mgTP/mgVSS (4.7   13.5% TP in the sludge) as against stoichiometric value of 0.0267 mgTP/mgVSS resulting in 1.76   5.04 fold. The maximum uptake was obtained at less than 6.41 gVSS/gVSS recirulatio ratio corresponding to 2 L/d Qrs sludge flow to anaerobic tank. Any further increase would have caused deterioration in uptake.

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Phase Distribution and Chemical Partitioning of Metals in Wastewater systems

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Abstract

An evaluation of the phase distribution for Chromium (Cr), Cadmium (Cd), Copper (Cu), Lead (Pb) and Zinc (Zn) along with its chemical speciation were carried out in the wastewater samples.Total metal content of wastewater sample collected from aerobic & anaerobic wastewater treatment plant is more than the total metal content of wastewater sample collected from domestic wastewater treatment plant. **Decreasing trend of metal concentration is observed during treatment process in case of Aerobic & Anaerobic (UASB-DHS) waste water treatment plant.Dissolved fractions were much higher than the particulate fractions in case of Aerobic & Anaerobic waste water (UASB-DHS) samples than the Domestic waste water samples.** Results obtained from model calculations using MINTEQA2 indicated that free metal ions and carbonates were dominant in the inorganic fractions in wastewater samples. The availability of Znas free ions is more compared to Cu, Cr, Cd and Pb in both the wastewater samples Metal forms more complexes with the CO_3^{2-}, Cl^- and NO_3^- compared to other cations or anions. The mobility and transport of Cu, Cd and Pb were influenced by the anionic ligands, organic matter and Zn by the non-anionic ligands in the wastewater system.

Keywords: *speciation, heavy metals, wastewater, UASB, DHS, MINTEQA2*

1. Introduction

Heavy metals are ubiquitous in the environment, as a result of both natural and anthropogenic activities. Wastewater is any water that has been adversely affected in quality by anthropogenic influence and comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. Many methods have been developed to address this stringent environmental regulation which necessitates removal of heavy metal compounds from wastewater. Up-flow Anaerobic Sludge Blanket (UASB) reactor is considered to be one of the most successful anaerobic systems, capable of forming dense aggregates by auto immobilisation and consequently allowing high-rate reactor performance [1]. Down-flow Hanging Sponge (DHS) process uses polyurethane sponge as media to retain biomass. Wastewater is trickled from the top of the reactor and purified by microorganisms retained both inside and outside of the sponge media as the wastewater flows vertically down through the reactor. In the light of the above discussion, it was decided to study the behavior of metal in waste water and sludge. The objectives were to (a) study the distribution of Cd, Cr, Cu, Pb and Zn between dissolved and particulate phases in wastewater samples, and (b) assess the chemical speciation in wastewater samples through MINTEQA2 speciation modeling and partitioning coefficient calculations.

2. Material and methods

Samples were collected from two different waste water treatment plants (WWTPs). Seven waste water samples were collected from sewage treatment plant at IIT, Guwahati during August 2014. The samples were designated as waste water (Inlet, ST1, ST2, ST3, AT1, AT2 & Effluent). Four waste water samples were collected from Agra_78MLD UASB+DHS plant Sampling, Agra during March 2015. The samples were designated as waste water (Sewage, UASB, DHS & FPU). The waste water and sludge samples were stored below 4ºC until analysis to minimize chemical alteration. The parameters like Ca^{2+}, Na^+, K^+, HCO_3^-, PO_4^{3-}, Cl^-, SO_4^{-2} and NO_3^- were analyzed by using standard methods [2]. Suspended solids (SS) were measured gravimetrically by filtration on to pre-dried and weighed filter paper (0.45 m). The concentration of Mg^{2+}, Cu, Cd, Cr, Pb and Zn was determined by inductively coupled plasma-optical emission spectroscopy (ICP-OES, Perkin Elmer DV-2100, Germany). Total metal contents were extracted by acid digestion method (Conc. HNO_3 70% + HCl = 3:1).

3. Results and discussion

The distribution of dissolved and particulate element concentrations of Cr, Cu, Cd, Pb and Zn in domestic and Aerobic & Anaerobic waste water samples are shown in logarithmic scale [Fig. 1 (a-e) and Fig. 2 (a-e)]. Particulate fractions for all five metals were much higher than that of dissolved fraction may be attributable to the undesirable impurities present in it. Particulate metal (Cu, Cr, Pb and Zn) was found at all the monitored sites of the wastewater treatment plant but for Pb at sites ST3 and AT2 no particulate fractions were found. No specific trend in the mobility or distribution of heavy metal as they move from one treatment process to another. In general, dissolved to particulate fraction ratio was found highest for Pb followed by Cr, Zn and Cu, which implies that bioavailability order for these metals will be Pb>Cr>Zn>Cu. Metals are positive ions, their affinity for anions will be more pronounced than the cations.

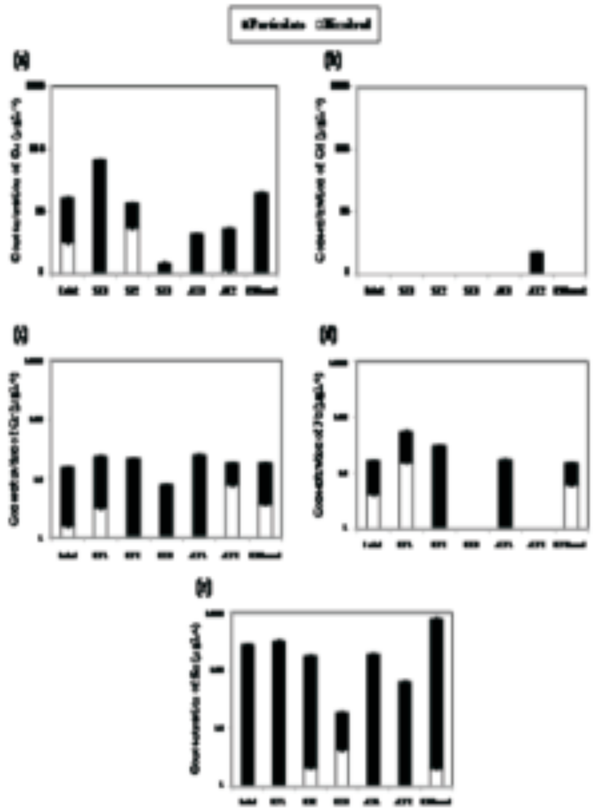

Fig. 1: Concentration of (a-e) Dissolved and Particulate metal (in log values) in domestic waste water.

Dissolved fractions for all five metals were much higher than that of particulate fractions. Excluding Cr, Pb and Cd, the dissolved and particulate fractions were found in the both the metals (Cu and Zn) of the wastewater samples. Specific trend is observed in the mobility or distribution of heavy metal as they move from one treatment process to another i.e the concentration of dissolved metal decreases. In general, dissolved to particulate fraction ratio was found highest for Zn followed by Cu, Pb, Cr and Cd, which implies that bioavailability order for these metals will be Zn>Cu>Pb>Cr>Cd. The wastewater samples collected from domestic wastewater treatment plant shows relatively low dissolved fractions of metals in compared to the samples from Aerobic & Anaerobic wastewater treatment plant.

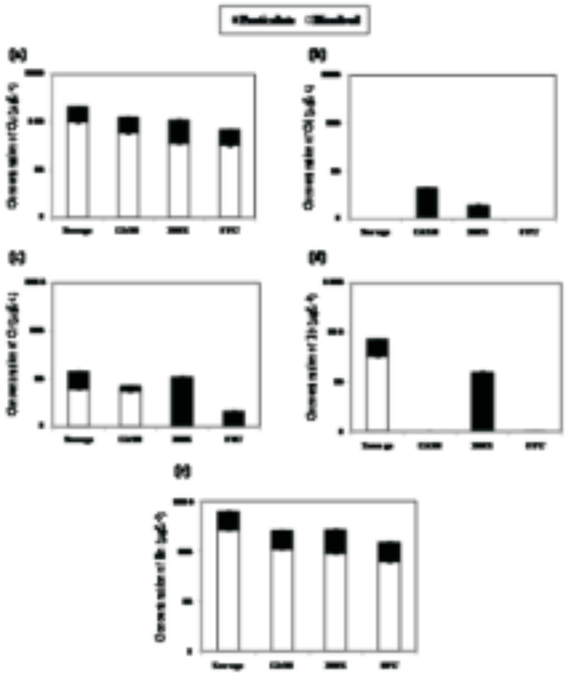

Fig 2: Concentration of (a-e) Dissolved and Particulate metal (in log values) in Aerobic & Anaerobic waste samples

4. Conclusions

The present research was focused on assessing the metal distribution between the dissolved and the particulate phase of the wastewater samples and the chemical partitioning of the sludge samples. The toxicity and bioavailability of metal is controlled by particular chemical form and not its total concentration. Metals were found substantially higher in particulate forms (upto 100 %) in wastewater samples of both the waste water treatment plants. For waste water samples collected from domestic waste water treatment plant, dissolve to particulate fraction ratio was found highest in Pb followed by Cr, Zn and Cu, which implies that bioavailability order for these metals was Pb>Cr>Zn>Cu>Cd. Whereas in case of waste water samples collected from aerobic & anaerobic waste water treatment plant, the bioavailability order for these metals was Zn>Cu>Pb>Cr>Cd.

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Operation and maintenance issues with full scale UASB reactors treating sewage in India

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Abstract

Present study investigates the performance of upflow anaerobic sludge blanket reactor (UASB) based sewage treatment plants (STPs) and their operation and maintenance (O & M) issues installed in North India.Eleven STPs of varying capacity of 10 154 million litres per day (MLD) were selected for present study. The extensive monitoring was carried out on the grab and composite samples collected at different locations of STPs for over a year. The most of the STPs were operating either under or over the design capacity, three STPs out of operation and one UASB was found under repair and maintenance. The effluent from several plants failed to meet the disposal standards.On the basis of results, it was observed that the STP with 38 MLD capacity at Saharanpur and 111 MLD at Ludhiana found most efficient in removing the total suspended solids (TSS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) compared to other STPs. During monitoring, the major flaw was observed in the lack of motivation, knowledge, and proficiency in operation and maintenance among technical personnel and could be the most crucial reason for poor functioning of UASB reactors.

Keywords:*Sewage,UASB, Operation and Maintenance, Biochemical oxygen demand, Chemical oxygen demand*

1. Introduction

UASB reactorshave been widely used to treat variety of industrial and domestic wastewaters all over the world. During late 1980s, UASB technology was widely applied at STPs due to its several advantages. In fact the world's first full scale UASB (5 MLD capacity at Mirzapur, Kanpur) was installed in India. The primary cause of selection of this technology was its low energy requirement. Presently 75 UASB based STPs are under operation in India. During early 1980s, the focus of the Government was to treat the sewage at low cost and less energy demanding technology. The disposal standards were not so stringent and UASB effluent was quite comparable to the disposal criteria during that time [1] But for last couple of years, due to strict effluent disposal standards in order to minimize the pollution and improve the quality of the surface water bodies especially rivers, the UASB reactors becomes the topic of discussion among decision makers and researchers. Due to its several benefits, government doesn't want to dismantle this technology but emphasizing on its retrofitting or modifying it by a suitable technology and focusing on the root causes of its poor performance. Therefore, the primary goal of this study was to find the major cause of the poor functioning of the UASB reactors and on its performance.

Parameter	Raw	After Preliminary Treatment	UASB Treated Effluent
Total Solids (mg/L)	600-900	500-600	150-300
Tot. Vol. Solids (mg/L)	400-440	250-390	60-100
TSS (mg/L)	200-450	150-350	30-50
VSS (mg/L)	150-250	140-200	20-50
BOD (mg/L)	120-250	110-240	40-90
COD (mg/L)	260-550	250-500	120-180
NH_4-N (mg/L)	25-45	20-45	20-40
PO_4-P (mg/L)	5-15	5-15	5-15

Table 1: Monitoring of UASB based STPs

2. Material and methods

Following STPs were investigated for evaluation of treatment performance and O & M issues, 111, 152& 48 MLD at Ludhiana, 38 MLD at Saharanpur,78 MLD at Agra, 40 MLD at Karnal, 37 MLD at Indrapuram, Ghaziabad, 72 MLD at Vijaynagar, Ghaziabad, 20 MLD at Faridabad and 20 & 35 MLD at Panipat having UASB-aeration-FPU for more than one year(March,2016- March, 2017) (Table1). Grab and composite samples were collected for analysis and stored inplastic containers and brought to laboratory. The Physico-chemical analysis of wastewater samples were carried out according to the standard methods [2].

3. Results and discussion

The typical values of domestic wastewater at various STPs are presented in Table 2.

STPs	Monitoring Schedule	Sampling Type	Frequency of Sampling (n)
Saharanpur (38 MLD)	2016-2017	Grab/ Composite	15
Agra (78 MLD)	2016-2017	Grab	3
Karnal (40 MLD)	2017	Grab	3
Indrapuram, GZB (37 MLD)	2017	Grab	2
Vijay Nagar, GZB (72 MLD)	2017	Grab	3
Ludhiana (111 MLD)	2016-2017	Grab/ Composite	16
Ludhiana (152 MLD)	2016	Grab	2
Ludhiana (48 MLD)	2016	Grab	1
Faridabad (20 MLD)	2016	Grab	2
Panipat (20 & 35 MLD)	2017	Under Repair	

Table 2:Typical values of domestic wastewaters at various STPs.

The STPs at Saharanpur(38MLD), Karnal(40MLD)andLudhiana(111MLD)are more efficient in removing TSS, BOD and COD *i.e*. 60%, 60% and 65% ; 54%, 60% and 62% ;64%, 66% and 59% respectively as compare to the STP's at the locations (Figure.3).As expected the nutrient removal efficiency was not very high. Low ammonical nitrogen removal efficiencies are quite common with UASB reactors and facultative pond systems because nitrification and denitrification processes are very insignificant. Phosphorus and nitrogen (20-45 mg/l and 5-15 mg/l) levels in the treated effluent are high enough to cause eutrophication problems in the receiving water bodies. Causes of poor performance areO & M and funding issues*i.e*. accumulation of scum on UASB reactors, clogging of inlet pipes & silt and grit accumulation in reactors (Figure4).

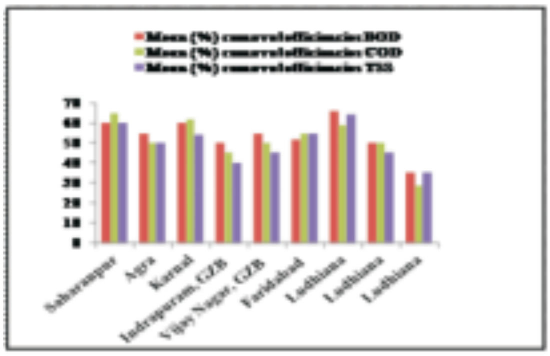

Figure 3:Summary of performance of full scale UASB reactors

Figure 4: UASB reactors at different STPs

4. Conclusions

The overall performance of all STPs in terms of BOD, COD and TSS ranged 40 to 60%. However, 111 MLD Ludhiana and 38 MLD Saharanpur STPs were performing well.The treated effluent is not in compliance with the effluent standards. TSS removal in PP is significantly good while negligible removal of nutrients observed. Hence, extensive studies are required to reach on consensus of a suitable post treatment system using aerobic granular biomass.

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Treatment options for grey water reuse in residential buildings

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Abstract

The non-fecal domestic wastewater is known as grey water. 50-80 % domestic wastewater comprises as grey water which may be reuse for various purposes such as toilet flushing, gardening, construction water, car washing etc. However reuse may require suitable treatments. Literature suggests various treatment options. The present paper will provide a review of various treatment options which could be suitable for reuse of grey water in Patna city area.

Keywords: Greywater; black water; wastewater treatment; reuse.

1. Introduction

Urban areas require artificial infiltration facilities. Availability of water is the most important factor for the development and prolonged existence of any civilization. Without adequate presence of fresh water, socio-economic development simply cannot take place. Consequent to rapid growth of population coupled with increasing demand of water for various purposes resulted in continuous declining in per capita availability of water and thus very soon water will be categorized as a rare resource in the world. Data indicates that availability of per capita surface water in India in 1991 was 2300 m^3, which reduced to 1980 m^3 in 2001. Further it is estimated to reduce upto 1401 and 1191 in year 2025 and 2050 respectively (Kumar et al., 2005).

Most of the Indian city and several parts of Indian rural areas do not have access of at least drinking water. In India, about 800 million people do not have clean water to drink. Every day nearly 1,600 children die from only diarrhoea. Some villagers do have access to clean drinking water at the cost of more than half of day spending in traveling for the search of drinking water. Population increase and urbanization are responsible for shortage of safe drinking water. Natural calamity coupled with anthropogenic activity further aggravated the situation of drinking water availability in India and other developing country.

Patna, capital city of Bihar state (India) is an ancient city earlier known as Pataliputra situated on the bank of holy river Ganga. The city is getting recognition as hub of commercial, industrial, political and institutional activities. Since past decade, commercial and residential high rise buildings are mushrooming along with single dwelling residential house. Increasing trends are expected to be continued in coming years. Presently groundwater is the only source of municipal water supply of the city to feed nearly 180 million populations using 35 pump house spread over the city. Current trends exhibit shortage of water in respect of quantity and quality both. Occurrence of arsenic and fluoride contamination in groundwater due to unknown reason is a major cause for additional deterioration of water quality. In spite of acute shortage of water, the city does not have any facilities for reuse of wastewater for any purposes. Though, literatures indicates that grey water may be reuse at least for flushing the toilet, irrigation and gardening, floor/road, dust suppression, construction and car washing (Kaur, 2010; Panjane and Sane, 2011). Grey water is non-industrial wastewater generated from domestic processes such as washing dishes, bathing and laundry. Grey water is distinct from black water in the amount and composition of its chemical and biological contaminates (from faces or toxic chemicals). Dish, shower, sink, and laundry water comprise 50-80% of domestic wastewater (Emerson 1998; Diana et al., 1996).

The paper will review the available treatment options of possible reuse of grey water in residential buildings and their suitability for Patna city area.

2. Material and methods

Literatures related to reuse of grey water will searched from various sources such as science direct, j-gate, ASCE, Ph.D. and M.Tech thesis of various institute/universities to find out the treatment options. The information gathered from the above sources will be analyzed for their suitability for Patna city area.

3. Results and discussion

Results and discussion will contain a critical review of grey water treatment and their suitability for Patna city area.

4. Conclusions

A critical review of treatment techniques for gray water is presented. The appropriate technique is identified for treating gray water that is suitable to Patna city. This reuse technology will help to reduce municipal water demand.

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Upgradation of CETP Effluent for Non-Potable Reuse

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Abstract

Performance evaluation of 4.5 MLD Plant CETP(Common Effluent Treatment Plant) at SIDCUL(State Industrial Development Corporation of Uttarakhand Limited), Haridwar was carried out in order to ascertain the water quality parameters and heavy metals in the effluent, and compare them with the norms of the Indian Effluent Standards and CPHEEO guidelines for non-potable reuse[1-2]. Various tests were conducted at primary and tertiary treatment stages in order to satisfy effluent standards for reuse. For removal of heavy metals, chemical precipitation method was used at varying pH from 7 to 11 at lab scale in which 1 N NaOH was used to vary pH. The removal percentages at different pH were studied in order to determine optimum pH for heavy metal removal by chemical precipitation.The optimum removal percentage of all heavy metals was observed at pH 8.The same experiment was performed at CETP atSIDCUL as a field trial. The pH was adjusted to 8 using lime and maintained throughout the experimental period. On fourteenth day the samples were collected from all stages of treatment for analysis of heavy metals.

A combination of Tertiary coagulation, Ultra-filtration (UF) and ozonation was performed in order to further reduce Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), turbidity and colour as per reuse standards.

Keywords: Common Effluent Treatment Plant;chemical precipitation; Tertiary coagulation; Ultra-filtration; Ozonation.

1. Introduction-

New discharge levels for waste water and tight restrictions on environmental standards combined with water shortage has prompted non potable use of waste water. These emerging challenges have encouraged use of new/existing technologies for treatment of CETP effluent at a commercial scale.

The aim of this study is to conduct various experiments on CETP effluent which is highly polluted with domestic sewage and industrial effluent using various existing treatment processes with an aim to propose a treatment mechanism which can treat any type effluent which is as highly polluted as CETP effluent, into prescribed reuse standards.

2. Material and methods

Removal of heavy metals. Chemical precipitation method at varying pH was performed for removal of heavy metals [3]. Amount of lime and alum was fixed at 100 and 0.5 ppm respectively using jar test. The pH was varied from 7 to 11 using 1N NaOH. Experiment similar to jar test was carried out at different pH simultaneously. Supernatants were extracted and analysed for heavy metals.The optimum removal percentage of all heavy metals was observed at pH 8.

A field trial was carried out at CETP at SIDCUL to ascertain the result. The pH was maintained at 8 using commercial lime. The plant was run for 14 days at pH 8 and samples were collected after all stages of treatment for heavy metal analysis.

Tertiary Coagulation followed by Ultra-Filtration. Tertiary coagulation combined with ultra-filtration process was carried out to reduce TSS, turbidity, BOD, COD and colour [4]. Alum and polyelectrolyte doses were fixed at 100 and 0.8 ppm respectively using standard jar test procedure. The supernatant was subjected to ultrafiltration which was carried out by using an Ultrafiltration membrane made up of Polysulfone at 15 PSI pressure. The effluent was analysed for TSS, turbidity, BOD, COD and colour. All parameters except colour satisfied using reuse standards.

Colour Removal by Ozonation. Ozone itself is a strong oxidizing agent and has a high efficiency of color removal [5]. The experiment was performed using an Indoz model ozone generator in which ozone dose was provided and samples were analysed in one minute interval.

3. Results and discussion

Removal of heavy metals.The percentage of removal of various heavy metals varied from 50% to 100% at various pH intervals. The optimum removal percentage of all heavy metals was observed at pH 8. At pH 8 all the heavy metals were within Indian Effluent Standards.Fig 1 shows variation in percentage removal of heavy metals

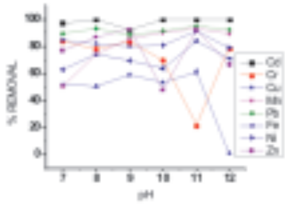

Figure 2.Variation in percentage removal of heavy metals with pH.

The field trials were necessary to analyse presence of heavy metals when the waste water undergoes secondary and tertiary treatment processes after chemical precipitation. During field trials high removal percentage varying from 63% to 95% were achieved for all the heavy metals. Except Fe all other heavy metals were within effluent standards.

Tertiary Coagulation followed by Ultra-Filtration. This combined process was able to reduce BOD by 77%, COD by 76%, and turbidity by 96% and TSS by 100% and all these parameters were within the reuse guidelines.Though the colour removal achieved by 52%, it was 42 in Pt-Co scale which was less not within the reuse limits. Overall the combines process of Tertiary coagulation followed by ultrafiltration was much effective than existing tertiary treatment process consisting of Pressure Sand Filter and Activated Carbon Filter. This has been summarised in Table 1.

Parameters	Modified Tertiary Treatment			Existing Existing Sand & Activated Carbon Filtration	Effluent Standards
	Secondary Effluent	Tertiary Coagulation	UF		
BOD (mg/L)	37	18	8.0	17	≤10
COD (mg/L)	[illegible]	24	13	21	[illegible]
Turbidity (NTU)	12.4	5.6	0.5	3.8	<2
TSS (mg/L)	14	8	ND	8	[illegible]
Colour (Pt-Co scale)	88	55	42	60	15

Table 1. Results of Tertiary Coagulation followed by Ultra-Filtration and its comparison with Existing Tertiary Treatment Processes.

Colour Removal by Ozonation. An exposure of 2 minutes with ozone concentration of 4.2 mg/L could remove the colour from the wastewater within reuse standards. With exposure 4 minutes with ozone concentration of 8 mg/L, the colour removal was achieved up to 88%.

4. Conclusions

The reuse guidelines laid down by CPHEEO are very strict in terms of turbidity, BOD, TKN and NO_3-N. Hence, in order to satisfy these reuse guidelines, additional treatment methods are necessary. In this study, attempts been tried for heavy metal removal by chemical precipitation at optimum pH. Attempts have been made to remove BOD, COD, TSS and turbidity by tertiary coagulation followed by UF. Finally ozonation has been performed for colour removal.

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Environs Of Arsenic & Heavy Metal Contamination In Aquifers Of Eastern Part Of Bardhaman District, West Bengal

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Abstract

Arsenic contamination of ground water is most striking in meandering zone of Bhagirathi River in parts of study area, which includes 6 blocks of Bardhaman district, West Bengal. Laterally, the effect of contamination diminishes away from meandering zone. The severity of contamination is more in shallow aquifers than both in phreatic and deeper aquifers. Potable ground water can only be tapped from deep aquifers. In shallow well, higher concentration of As is associated mostly with higher concentration of Mn and Ni.

Keywords: *Contamination, aquifer, Bhagirathi River, arsenic, meandering*

1. Introduction

Long-term intake of arsenic contaminated water leads to arsenic poisoning or the arsenicosis. In West Bengal, 83 blocks in 8 districts of West Bengal are affected by arsenic > 0.05mg/l (BIS, 2012 permissible limit). WHO Guideline (2011) value for arsenic in drinking water is 0.01 mg/l.

The study area comprises six blocks, viz. Katwa-I, Katwa-II, Manteswar, Purbasthali-I, Purbasthali-II and Kalna-I of Bardhaman district in Bhagirathi River Basin. The area lies between 23^{0}15' and 23^0 39' N and between 88^{0}04' and 88^0 23' E. The mighty Bhagirathi River, which flows from north to south control the drainage of the area. Due to shifting of meandering courses from west to east over geological time scale, many geomorphic elements developed in the area, viz. natural levees, paleo-levees, back swamps, abandoned channels, point bars, channel bars, etc.

The objective of this study is to analyze vertical and lateral variation of the concentration of arsenic and other heavy metals in ground water of different aquifers with respect to geomorphic elements of the area.

2. Material and methods

Fifty-five groundwater samples were collected during pre-monsoon. Samples were collected from different locations in meandering zone and away from it, at varied distances from River Bhagirathi. Mostly, 3- set samples have been collected from phreatic, shallow and deeper aquifers at each location. The samples have been analyzed in the laboratory of Geological Survey of India. Beside arsenic (As), heavy metals, viz. Ti, Mn, Ni, Se, Pb and Cr have been analyzed by ICP-MS.

3. Results and discussion

3 aquifers delineated in the sub-surface of the study area are: i) phreatic aquifer under unconfined condition, ii) shallow aquifers up to a depth of 60 m bgl under semi-confined condition and iii) deeper aquifers below 60 m bgl under semi-confined to confined condition. Summarised data of As concentration in ground water in different aquifers are given in Table 1.

High concentration of Arsenic in ground water has been encountered within shallow aquifers, mostly in and around meandering zone, commonly in association with higher concentration of Mn and Ni. As in ground water is less away from the meandering zone in southern and western sectors.

4. Conclusions

As contamination diminishes towards west and south, away from meandering zone of Bhagirathi River. The severity of contamination is more in shallow aquifers and less both in phreatic and deeper aquifers. In shallow well, higher concentration of As is associated mostly with higher concentration of Mn and Ni.

Potable ground water can only be tapped from deep aquifers.

Table 1: As concentration in ground water in different

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Shallow [illegible]	[illegible]	22	[illegible]	6	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

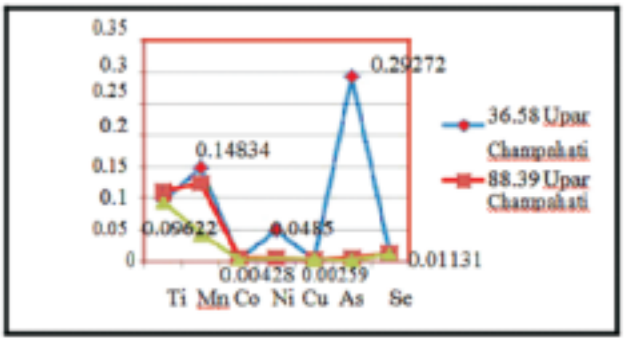

Fig.1: *Trace element concentration (mg/l) in groundwater of shallow and deep tube wells at Champahati, Purbasthali I block*

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An attempt to understand the mechanism of recharge in the mountain front and the riparian zone aquifers using integrated techniques

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Groundwater is a major source of freshwater for the domestic and agricultural activity. Geologically, the area is characterized by hard rock aquifers made of different rock types like Charnockite and Hornblende Biotite. The occurrence and movement of groundwater are controlled by various factors like physiography, climate, geology and structural features like lineament and dykes. To understand the grounder water level variation, 3 piezometers were installed in 3 bore wells of selected locations namely Kadayam, Tenkasi and Panpoli. The daily water level data of 8 hours interval has been continuously recorded. This study reflects that a large scale temporal and spatial fluctuation of water level and localized ground water recharge in the aquifers of the area. As the region is located near the foothills there is an immediate recharge after the monsoon at the mountain block. Daily water level data has been compared with rainfall data to know the water level response to these hard rock aquifers. The highest rate of water level rise and its variation is seen along the region away from foothills which acts as a potential zone and gets recharged from hilltops. There are also signatures of other water type along the foot hills indicating agricultural return flow and recharge of evaporated water sources like tanks and river. From the statistical analysis it is inferred that weathering is the major process which controls the chemical composition of ground water as well as recharge along the foot hill. Both silicate and carbonate weathering is dominant along the foothill region, with relatively higher fraction of Mg from the mountain front as mountain is predominantly of Charnockites. Foothill aquifers are depleted and on the contrary riparian zone aquifers are enriched in the isotopic composition. Thus it is inferred that the rainfall along the foothills, contributes recharge to the riparian zone (basin block region) whereas foothill regions receive recharge from rainfall from the mountain block.

Keywords: Water level, Foothill, Riparian zone, Isotope.

Isotopes (δ^{18}O and δD) in precipitation and groundwater in the alluvial basin of Kashmir western Himalayas

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Abstract

The characteristics of δD and δ^{18}O in precipitation and groundwater have been used to understand the groundwater flow system in the alluvial basin of Kashmir valley. The slope of precipitation samples was lower than global and local meteoric water line signifying the secondary evaporation during rainfall. The changes in stable isotopes of precipitation at each station suggests the seasonal changes in ambient temperature, precipitation, source of moisture and airmass trajectory. The groundwater samples fall close to local and global meteoric water line indicating groundwater is of meteoric origin. The lower values of d-excess in groundwater supports the fact that there is a significant evaporation on the groundwater system. Nitrate content associated with shallow groundwater samples indicates that local seepage is contributing towards the recharge of these wells.

Keywords: Groundwater, stable isotopes,

1. Introduction

Kashmir Valley with abundant fresh water resources in the form of glaciers, rivers/streams, lakes, springs and groundwater are used for various purposes including irrigation, hydropower generation and recreational purposes (Jeelani et al., 2013). The demand of fresh/usable water has increased due to rapid growth of population and infrastructure affecting various sectors. To meet their demand of fresh water, there is an enormous stress on ground water resources as the surface water pollution is increasing day by day. In this study stable isotopes of oxygen and hydrogen (δ^{18}O and δD) were used understand the groundwater flow system in the alluvial basin of Kashmir. Stable isotopes of oxygen and hydrogen have tremendous significance in water resources development and management, their spatial and temporal variation in groundwater is essential for any hydrological study. The study area (Kashmir valley) lies between the geographical coordinates of latitudes 33°55'00? & 34°35'00? N and longitude 73°50'00? & 75°20'00? E.

2. Material and methods

Groundwater samples n=51 and Precipitation samples n= 60 were collected during 2013 in the Kashmir valley (Fig 1). Five precipitation sampling stations were setup to collected bulk rain samples. All analysis was done at National Physical Research Laboratory (PRL) Ahmedabad.

3. Results and discussion

The δ^{18}O‰ and δD‰ values of precipitation samples varied from -15.58‰ to -0.12‰ and -112.38‰ to -2.32‰ with an average of -6.05‰ and -38.07‰. The precipitation samples collected at Gulmarg (2300 m, asl), Achabal (1800 m, asl) and Palapora (2080 m, asl) station were relatively depleted compared to precipitation samples collected at Dara (1720 m, asl) and Magam (1680 m, asl) precipitation stations. This difference in stable isotopic signatures is ascribed to their difference in altitude (Fig.1).

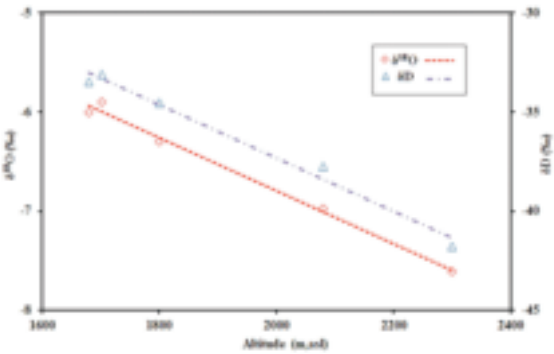

***Fig.2. Decrease in** δ^{18}O and δD with increase in altitude in precipitation samples at different stations.*

The estimated mean altitudinal effect was -0.27**‰** and -1.59**‰** per 100 m change in altitude for ä^{18}O and ä^{2}H**.** The precipitation samples are highly depleted in the month of January and enriched in the month of July. The changes in **isotopic ratio of** δ^{18}O **and** δ**D** signifies seasonal change in ambient temperature and precipitation amount (Fig.2). In June and July, the increase in stable isotopic composition is attributed to decrease in precipitation amount(Fig.2). The depleted isotopic values observed in the month of augest at each station may due to the rainout effect during moisture transport.

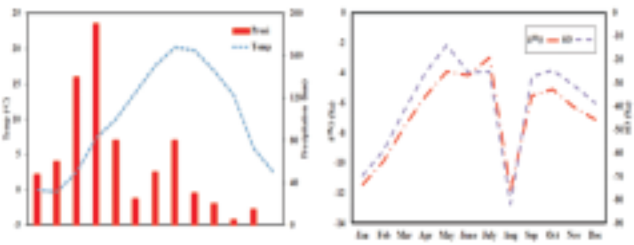

Fig. 3. Average stable isotope composition of precipitation and their relation with ambient temperature and precipitation

Stable Isotope variation in Groundwater

The δ^{18}O and δD values of groundwater samples ranges from -10.97‰ to -0.73‰ and 68.16‰ to -0.02‰ with an average value of -6.82‰ and-40.88‰. The d^{18}O and dD values of group (I) varies from -8.33‰ to -10.03‰ (mean -9.18‰) and from -49.49‰ to -62.51‰ (mean - 56‰). These samples were collected from the upper most parts of the basin. The precipitation experiencing in the higher elevations of the basin would recharge this part directly. The δ^{18}O‰ and δD‰ of group (II) varies from - 4.49‰ to -7.01‰ (mean -5.9‰) and -30.55‰ to -38.4‰ (mean -34.4‰). These groundwater samples were collected from middle part of the basin suggesting enhanced contribution of shallow groundwater and surrounding water together with precipitation inputs for the groundwater recharge. The δ^{18}O‰ and δD‰ of group (III) ranges from -2.78‰ to -4.08‰ (mean -3.92‰) and - 15.53‰ to -18.11‰ (mean -16.52‰). These isotopic signatures were observed in those wells are located towards the lower part of the basin. Contribution of surface water for the groundwater recharge is more significant in these areas. high nitrate content is associated with groundwater samples enriched inδ^{18}O supports the fact that local seepage is contributing towards the recharge of these wells.

D-Excess:

The d-excess values of precipitation samples ranged from 26.81‰ to -11.74‰ with an average value of 15.81‰ (Fig.6).

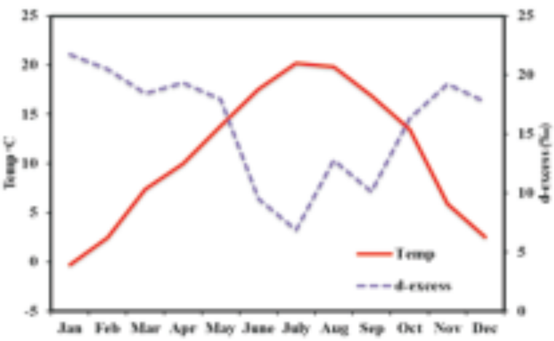

Fig. 6. Seasonal variation in d-excess and temperature

The observed average d-excess values were higher from October to May and lower in the months of June, July and September. Higher d-excess values from the month of October to may signifies that western disturbances are dominant source of moisture during these months. However, Lower d-excess in the months of June, July and September with higher δ^{18}O and lower precipitation amount signifies the effect of secondary evaporation. The d-excess values of groundwater samples ranges from 20.52‰ to -5.86‰ with an average value of 13.99‰. The lower values of d-excess in the groundwaters at most parts of the study area supports the fact that there is a significant evaporation effect on the groundwater system

4. Conclusions

The study revealed that the enriched stable isotope composition of precipitation (ä^{18}O and äD) with lower d-excess and lower precipitation amount as well as lower slope and intercept signifies the effect of secondary evaporation.The depleted isotopic values observed in the month of augest are attributed to either due to the maximum flux of rainfall or due to the rainout effect during moisture transport. The groundwater samples fall close to GMWL and LMWL suggesting meteoric origin for groundwater system. The lower d-excess values observed in groundwater samples supports the fact that there is a significant evaporation on the groundwater system.

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Vulnerability of karst aquifer to contamination

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Abstract

In present study, we used hydrochemistry and travel time to evaluate the vulnerability assessment of groundwater in karst aquifers of the Kashmir Valley, India. Water samples (n=210) were collected monthly from some major karst springs besides five tracer experiments were also performed during the year 2013-2014. The study suggests that deterioration of quality of water and variation in the magnitude of flux are the two main consequences of short travel time of karst groundwater in the region. The sharp increase of NO_3^-(2 to 12 mg L^{-1}) and Cl^- (12 to 31 mg L^{-1}) with the onset of agricultural practices season and after the significant rain events suggest that the karst springs are vulnerable to contamination from point sources. The contamination of the karst aquifer, if remained unchecked, could pose a great threat to the health of the people using the water of the aquifer.

Keywords: *karst springs, water quality, vulnerability.*

1. Introduction

Understanding the sources and processes that control groundwater quality, timing and magnitude of groundwater vulnerability to potential surface water contamination is critically important for groundwater protection (Wong et al., 2012). This is especially true in karst terrains, where infiltrating surface water can rapidly affect groundwater quality. A widely recognized technique to assess the vulnerability of an aquifer lies in travel time evaluation (Ford and William,2007). Keeping in view the high permeability, short transit times and multifaceted importance of karst springs in the region (Jeelani et al., 2010), effective approaches are therefore required for the management and protection of karst groundwater resource. The objective of the present study is to evaluate the valunearbilty of groundwater in karst aquifers of the Kashmir Valley, India, to contamination.

2. Material and methods

2.1. Hydrochemistry

Water samples (n=100) were collected monthly during 2013-2014 for major ions from five major karst springs of the Kashmir Valley. The standard methods were adopted to analyse the dissolved chemical constituents.The physical parameters such as water temperature, pH, Electric conductivity (EC) measured in situ by HACH (HQD Sension$^+$). Turbidity was measured by Portable Fluorometer (GGUN-FL30).

2.2. Tracer method

Between August and October 2013, artificial tracer tests were carried out for only three major cold karst springs (Achabalnag, Martandnag and Andernag) to estimate the travel time. The tracer (first injection) was injected at three different geographical locations. Calibrated Portable Fluorometer GGUN-FL30 (Albilla Neuchatel, Switzerland) (Schnegg, 2002) was setup in each spring before tracer injection and remained onsite until tracer recovery ended. Backup sampling was also carried out after every 30 min.

3. Results and discussion

3.1. Hydrochemistry

During the monitoring period, both physical and major chemical ions in karst springs waters varied considerably both spatially and temporally. The order of abundance of cations followed Ca > Mg >Na>K>Fe and in anions the order follows HCO3 > SO4 > Cl > NO3 > F. It was observed that all major chemical constituents in spring waters exhibited more or less similar monthly and /or seasonal pattern. Except, NO_3^-, Cl^- and F^-,all the ionic constituents (Ca^{2+}, Mg^+, Na^+, K^+ Fe^{2+}, HCO_3^- and SO_4^-) exhibited higher amounts in December/January and lower in July/August months. NO_3^-, Cl^- and F^- showed higher their amounts during high flow period (May-September). The higher concentration of these ionic constituents in spring waters of the region is a strong evidence of speedy levels of anthropogenic activities within the source areas of the springs.

Scatter plot of Ca + Mg vs. HCO_3 (Figure A) shows that data falls above the equiline which suggest carbonate dissolution as a major sources of solutes besides some contribution from other sources. In Ca+Mg over HCO_3 +SO_4 (Figure A) dominancy of Ca and Mg over HCO_3 and SO_4 suggests the interaction of water- rock with silicate lithology also before emergence from the aquifer. Most of the data points lie above the aquiline in Na vs Cl^- plot (Figure A) which reflect the contribution from silicate lithology, because Cl is mostly

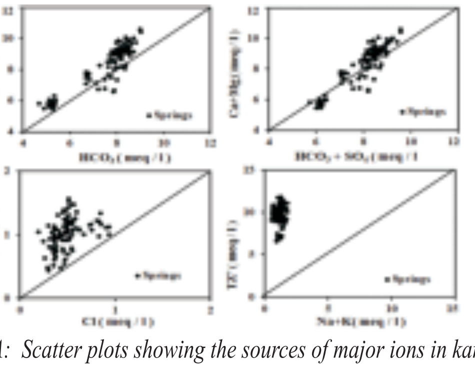

Figure A: Scatter plots showing the sources of major ions in karst springs

3.2. Tracer Tests

The dye tests for Achabalnag, Martandnag and Andernag karst springs remain successful and confirmed the hydrological connectivity between the injected tracer locations and the monitored springs. Results of dye tracing indicate that water from losing streams is directed towards the ridge through large joint controlled rift passages.

The tracer breakthrough curves (TBC), a primary result of tracer test, retrieved for different springs (Figure B) suggested travel time of groundwater from few days to a week. The retrieved TBCs revealed short travel time and rapid flow through well-developed conduit network, which reflect that groundwater in these aquifers is highly vulnerable to contamination.

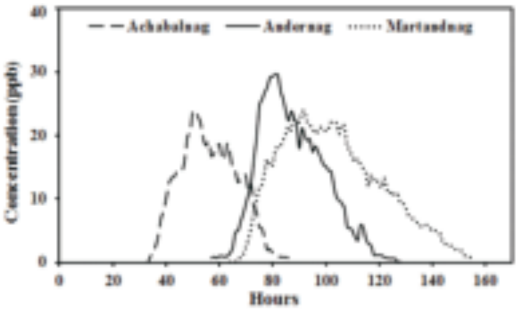

Figure B: Tracer break through curves of karst springs

4. Vulnerability assessment

The deterioration of water quality particularly the increase of faecal coliform, faecal streptococci and NO_3 is already reported (Jeelani, 2010). We have observed the rapid change of water colour from transparent to muddy (turbidity) soon after every significant rainfall event in Achabalnag. The identified point source of recharge to the Achabalnag is located nearby the residential area and cultivated agricultural fields. There was a significant change in water quality with increase in NO_3 concentration from 2 mg L^{-1} to 12 mg L^{-1} and Cl from 12 mg L^{-1} to 30 mg L^{-1} during summer due to agriculture return flow. Similarly, the point sources of recharge area of Martandnag is identified near Zajibal along Sheshnag stream. A lot of solid waste and faecal matter is thrown open to this nalla which has started deteriorating the water quality with increase in NO_3 concentration (9 mg L^{-1}). Keeping in view the importance of these karst groundwater resources and its vulnerability, the identified point sources of recharge and their catchment areas need to be preserved, conserved, managed and restricted from the anthropogenic activities.

4. Conclusions

We used hydrochemistry and tracer tests to evaluate the vulnerability assessment of groundwater in karst aquifers of the Kashmir Valley, India. The hydrochemical results suggest that congruent carbonate dissolution (calcite dissolution, dedolomitization), incongruent silicate weathering are the dominant processes controlling the spring water chemistry. The tracer break curves reflect short travel time and rapid flow through well-developed conduit network. The study suggests that deterioration of quality of water and variation in the magnitude of flux are the two main consequences of short travel time of karst groundwater in the region.

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Assessment of the impact of leachate percolation on ground water quality: A case study of Varanasi city, India

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Abstract

The leachate originated from waste disposal sites comprises various contaminants that have negative impacts on ground water quality. In the present study ground water quality was assessed from an open dumping site of Varanasi city, India and was compared with a control site. Concentration of various physico-chemical parameters including pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), Total hardness (TH), Alkalinity, Salinity and Dissolved oxygen (DO) were estimated. The results showed moderately high concentration of TDS, TH, alkalinity and salinity, and low DO as compared to the control sites. The study concludes that leachate from waste dumping site deteriorates the quality of ground water for drinking and other domestic purposes in Varanasi city.

Keywords:*Leachate; Open dumping site; Ground water; Varanasi*

1. Introduction

Rapid pace of increase in urbanization, industrialization and population growth has been accompanied by huge quantum of solid waste generation. This burgeoning amount of solid waste usually finds its way to landfills or open dumps, which are still the main centers for waste disposal [1]. Further, production of leachate from landfills or open dumps is of prime concern in the contemporary scenario due to its complex nature and noxious impact. It has been observed that landfill leachate comprises various toxic and carcinogenic compounds including heavy metals, ammonia, xenobiotics, personal care products etc.

thereby negatively affecting thesurface and ground water aquifers [2]. Areas in close vicinity to the landfills or open dumps have a greater possibility of groundwater contamination. Consequently, have a substantial risk to human health and to the natural environment [2]. A number of studies were performed in recent years to show the impact of landfill leachate on ground water quality [3,4].

In the present study, the impact of leachate percolation on ground water quality from an open dumping siteof Varanasi city, India was estimated and compared with a control site.

2. Material and methods

Ground water quality analyses was performed in adjoining areas of both dumping and control sites (<200 m) to assess its impact on health of people residing in close vicinity to the open dumping site. The sampling was performed in May 2015. For ground water analyses four samples were collected from adjoining areas of both the sites (<200m) and were stored in low temperature (4ºC). The analyses were performed according to the internationally accepted procedures as prescribed by APHA (1994) methods [5]. Different physico-chemical parameters of ground water like pH, Electrical conductivity (EC), Total Dissolved Solids(TDS), Temperature, Acidity, Alkalinity, Salinity, Total Hardness, Dissolved oxygen were analyzed and comparison was made with control sites.

3. Results and discussion

The pH was ranged between 7.19- 7.39 (about neutral) and EC was ranged between 1.05-1.36 μScm^{-1}in samples collected from dumping site that indicates the amount of materials dissolved in water. EC was found higher in Site1 and Site 2 of dumping site however it was lower than site 4 of control site (2.65$mScm^{-1}$) it may be due to the contamination of ground water aquifer from unknown source. Dissolved oxygen was found between 2.4-3.1 mgL^{-1} which was lower than samples collected from control site (2.5-7.06mgL^{-1}) clearly suggesting poor quality of ground water near dumping areas. Similarly, TDS was found higher (0.57-1.03 ppt) than control site. However, it was higher in Site 4 (1.47ppt) of control similar to EC at same site. The high concentrations of TDS may cause gastro-intestinal problem in human and may also have adverse effect particularly upon transits (WHO, 1997). Alkalinity was recorded comparatively higher in samples of dumping site (296-378.67mgL^{-1}) than control site (21.33-298.67 mgL^{-1}) (Fig. 1). The high alkalinity responsible for unpleasant taste, and may have negative effect on human health with high pH, TDS and TH. Likewise, TH and salinity was noted in higher concentration in samples collected from different sites near to open dump. In Site 4, TH was detected much higher i.e. 423.33mgL^{-1} and 860mgL^{-1} in both control and dumping site respectively than others samples (Fig.1). These values are higher than standards of BIS and WHO. An overview of physico-chemical properties of ground water have shown in Table 1

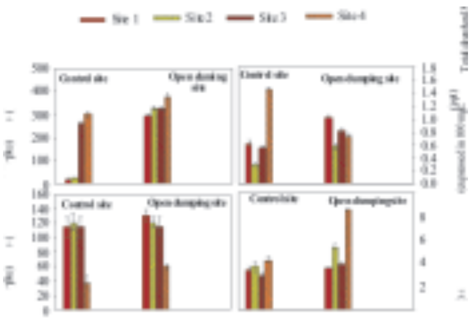

Fig 1. Comparison of physico-chemical properties of ground water samples collected from the adjacent areas of control and open dumping site

4. Conclusions

The high concentration of alkalinity, salinity, EC, TDS, THand low DO in ground water samples near open dumping site indicates that leaching from dumping site could pose a serious threat to the ground water aquifers that may have a negative impact on human health.

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Table 1. Ground water characteristics for sample sites adjacent to open dumping site (n=3, SD)

Parameters	Site1	Site2	Site3	Site4
pH	7.34 ± 0.02	7.19 ± 0.01	7.34 ± 0.05	7.39 ± 0.01
EC (mScm^{-1})	1.35 ± 0.01	1.36 ± 0.12	1.05 ± 0.02	1.25 ± 0.02
Temperature (°C)	34.30 ± 0.00	33.60 ± 0.10	33.60 ± 0.10	34.00 ± 0.00
DO (mgL^{-1})	2.4 ± 0.2	2.47 ± 0.12	2.53 ± 0.31	3.13 ± 0.41
Alkalinity (mgL^{-1})	296.0 ± 4.0	326.67 ± 6.11	325.33 ± 6.11	378.67 ± 10.07
Salinity (mgL^{-1})	130.17 ± 8.20	120.70 ± 7.10	115.97 ± 0.85	59.17 ± 4.10
TDS (ppt)	1.03 ± 0.01	0.57 ± 0.04	0.82 ± 0.03	0.74 ± 0.01
TH (mgL^{-1})	353 ± 5.8	540 ± 17	393 ± 15	860 ± 20

CO-OCCURRENCE PERSPECTIVE OF ARSENIC, FLUORIDE AND METALS IN THE AQUIFER OF LAKHIMPUR DISTRICT, ASSAM,INDIA

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Abstract

Arsenic (As) and fluoride (F^-) are known as geogenic contaminants of groundwater and are reported to be hazardous for human health. Although a number of works have been completed in the field of As and F^- hydrogeochemistry, yet the study of co-contamination perspectives has remained a largely unexplored area. Moreover,proper study of their hydrogeochemistry and co-contamination behaviour is lacking. Therefore, this study was conducted to understand the co-contamination behaviour of As and F^- in the Lakhimpur district of Assam. The study investigates the extent and distribution of the two contaminants depthwise ,the factors influencing the possible pathways for co-contamination and presence of potentially toxic elements (PTEs) Na, K, Ca, Mg, Cd,Mn, Pb, Zn, Co, Fe and Ni by BCR process. For this purpose, in order to achieve proper results, comprehensive sediment sampling was conducted for two season i.e., monsoon and post-monsoon including three sampling sites near three tributaries of the Brahmaputra river i.e Subansiri, Dikrong and Ranga .

Keywords: *Co-contamination;* potentially toxic elements (PTEs) .

1. Introduction

Worldwide many cases of As and F^- contamination have been reported and the number of countries under threat of toxic effects of these contaminants are increasing significantly. The countries affected by As are those where the dependence on the groundwater for drinking and irrigation is very high viz. China, India, Pakistan, Argentina, Chile, Mexico, Finland, Slovakia, Ghana, United States of America, Korea (Fawell et al., 2006; Farooqi et al., 2007a, Nickson et al., 2007; Armienta and Segovia, 2008; Berg et al., 2008; Gomez et al., 2009, Nicolli et al., 2012; Kim et al., 2012; He and Charlet, 2013, Wen et al., 2013). The co-occurrence of chronic poisoning of both As and F^- is becoming endemic to India especially in alluvial flood plains of the river Ganges and Brahmaputra where groundwater were reported to have As (Majumdar, 2011; Sharma et al., 2011; Kanaujia et al., 2013) and F^- Srikanth, 2013; Singh and Vedwan, 2014) beyond desirable limit in many places. The reasons for co-occurrence of As and F^- in groundwater can be both geogenic and anthropogenic but the major population exposure reported worldwide is due to ingestion of contaminated groundwater mainly from geogenic occurrences. - lacking. Hotspots like the Brahmaputra and Gangetic floodplains is lacking.

Study were to identify the degree of co-occurrence of As and F^- to evaluate their correlation with coexisting ions of the aquifer system. To the best of our knowledge, the co-contamination perspective of As and F^- is very limited from India (Kumar et al. 2016). Moreover, one of the primary factors which governs the mobilization of contaminants like As and F^- is their distribution in different soil/ sediment phases (Tessier et al., 1979). Actual toxicity of many contaminants like As which occur in soils and sediments have been found to be dependent on the relative ease with which the fractions leach out of solid phase rather than their total concentrations (in soil, sediments and minerals) (Wenzel et al., 2001; Kumar et al., 2009). Therefore, in light of the above factors, it is essential to understand phase distribution of different fractions of "interest" in soil and aquifer materials.

Sequential extraction procedure (SEP), is one of the most well established methods for extracting and understanding these "operationally defined phases" or fractions of soils/sediments with the help of "reagents of increasing dissolution strength" under laboratory conditions (Wenzel et al., 2001).). Among many sequential extraction protocols (Tessier et al., 1979; Zeien and Brummer, 1989), the sequential extraction procedure of the Community Bureau of Reference (BCR) has the advantage that it is well standardized (Ure et al.,1993; Quevauviller, 1998; Rauret et al., 1999; Bacon and Davidson,2008; Sutherland, 2010). It is a widely used technique and the results can be interpreted as 'operational fractionations' according to the definition ofUre (1991)and Ure et al. (1993).

2. Material and methods

For the present study, PVC pipes of 100 cm were used for collection of sediment during monsoon and post-monsoon period. Pipes were cut down into 10 cm length after they were brought to the laboratory.A total of 44 samples were obtained for analysis during monsoon and post-monsoon period. Samples were dried at 50°c for 24 hrs and stored at 4°c until further analysis. The coordinates of sampling sites were noted using a handheld GPS set (Garmin GPS map 76CSX). HANNA H19128 multiparameter water quality portable meter used for measuring Eh and ***pH*** (soil to water ratio is 1:5). Arsenic was analyzed using Atomic Absorption Spectroscopy (AAS, Thermo scientific ICE 3000). Fluoride concentration is measured by ISE-meter **(Ion selective**

electrode meter Thermo fisher scientific, STARA2140). Grain size fractionation was done by using sieving technique, a total of 6 sieve grades were used, which were: 4000, 2000, 500, 250, 125 and 63 µm.

BCR Sequential extraction procedure was used for cation extraction , fractionation of As was done by using the modified five step sequential extraction procedure (sep) developed by (*wenzel et al., 2001; hamon et al., 2004; haque et al., 2008*) (table 3) providing the SEP scheme.

3. Results and discussion

FractionIII (fig1) plays a very important role in occurrence of high groundwater As , which is further proved by the high correlation between groundwater As and fraction III . This fraction of As is reported to be associated with amorphous and poorly crystalline Fe (hydr)oxide like ferrihyferrihydrite, because of which this fraction was reported to be less labile than previous fractions (I and II) (*Wenzel et al., 2001; Haque et al., 2008*). Its mobilization has been reported to be associated with action of hydroxamated ligands and reducing conditions *(Wenzel et al., 2001; Haque et al., 2008; Holman and Casey, 1996).*The residual or the non-labile fraction, (fig1)which has been reported to be associated with sulphides like orpiment *(Wenzel et al., 2001; Haque et al., 2008)* is unaffected by normal conditions. Instead extreme conditions of oxidation or anthropogenic activities like mining which releases highly oxidizing acidic discharges have been suggested as key processes capable of mobilizing this fraction (*Smedley et al., 2002; Smedley and Kinniburgh, 2002*).Therefore less As is extracted from this fraction .

Figure1. Graph showing percentage As composition of fractions (a) monsoon (b) post-monsoon season .

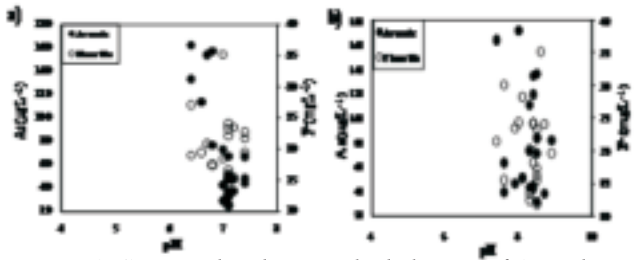
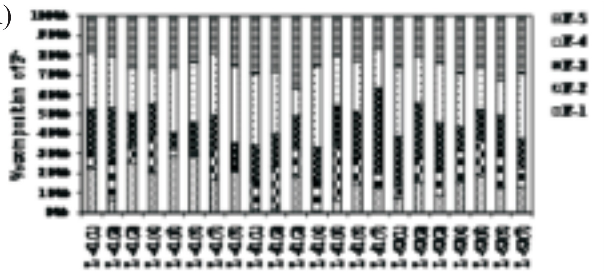


Figure2. Scatter plot showing the behavior of As and F⁻ with pH (a) monsoon (b) post-monsoon season.

- ✈ Both As and F^- is showing an increment with pH **.**
- ❑ Arsenic prefer more of alkaline condition .

(A)



(B)

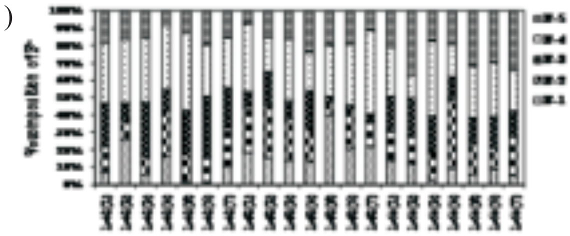


Figure3. Percentage composition of fluoride in fractions for (a) monsoon season *and (b) post-monsoon season .*

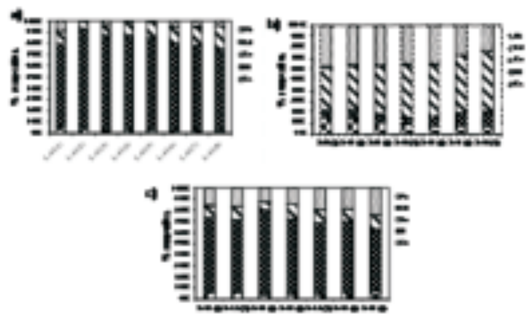


Figure4. Graph showing percentage composition of Pb ,Cd, Zn, Ni and Co in samples (a) Subansiri River (b) Dikrong river (c) Ranga River for monsoon season .

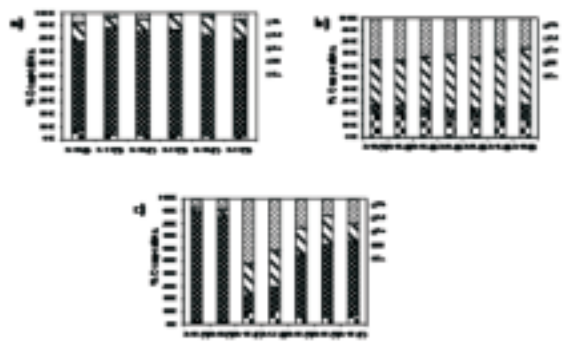


Figure5. Graph showing percentage composition of Pb ,Cd, Zn, Ni and Co in samples (a) Subansiri River (b) Dikrong river (c) Ranga River for post-monsoon season .

More of Ni content is observed in *Subansiri and Ranga River* samples with it more of Zn is observed in Dikrong River samples for both monsoon and post-monsoon .

4. Conclusions

Co-occurrence of As and F^- in groundwater is a less than understood subject, moreover it is very difficult to replicate in laboratory the exact set of conditions found in natural settings. Findings from the present study showcase the behaviour of As and F^- in reducing aquifers of the rivers. Significant correlation between total As and As extracted from fractions III and IV [Fe (hydr) oxides] suggests the main source of groundwater As was derived from Fe (hydr) oxide present in soils and sediments. Although the sulphide bound As fraction was significantly high (fraction V), yet it was not the immediate source of As in the groundwater.Fe (hydr) oxides phase (fraction III and IV) was the main phase associated with the co-contamination behavior of As and F^- in the laboratory settings. Desorption of both As and F^- was found to be affected by the pH of the groundwater. Increase in pH leads to reduction of net positive charge on the Fe (hydr) oxides substrates. Therefore the negatively charged F^- and oxyanions of As showed greater desorption at higher pH.

The BCR sequential extraction revealed contrasting geochemical distributions of As, Pb,Cd,Ni mostly geogenic enriched sediments. Future studies should also focus on the mobilization and phytoavailability of these elements in soil sediments as well as on the dissolved and colloidal fractions under dynamic redox conditions to further improve the understanding of the geochemical processes determining thedynamics of these pollutants in floodplain soils.

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Conservation of Urban Lakes in Coimbatore

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Abstract

This study attempts to assess the impacts due to urbanization on lakes and conservation measures to be taken in the context of the Coimbatore city, India. Coimbatore city has eight lakes/ tanks which have been studied here to know the issues pertaining in the area. This study is based on the primary data and secondary data collected through household surveys and reports respectively. Analysis of the issues is done using four methods namely, Morphometric study,
Water Quality Index (WQI)

Analysis, Socio-Economic analysis and Driving Forces - Pressures - State - Impacts - Responses (DPSIR) framework. The analysis values provide a useful measure of identifying problematic lakes that can be plugged through conservative measures to improve their quality and ensure urban lakes in Coimbatore moves on the right path.

Keywords: Urbanization; Conservation; Morphometric; WQI; Socio-Economic; DPSIR.

1. Introduction

Lake ecosystems are vital resources for aquatic wildlife and human needs, and any alteration of their environmental quality and water renewal rates has wide-ranging ecological and societal implications (1). The increasing accumulation of greenhouse gases in the atmosphere has begun to affect the structure, functioning, and stability of lake ecosystems throughout the world, and much greater impacts are likely in the future. It? provides food for aquatic wildlife. These? services are hampered by human activities. Human activities like poaching, waste disposal, immersion of idols and other activities which destroy lakes are of high concern in the recent days. Current global circulation models predict an increase in air temperatures by the end of the twenty-first century, combined with large changes in the pattern and intensity of rainfall. Prior studies mention that these problems can be tackled through conservation, but they do not specify how these measures can be implemented. Urbanisation has resulted in more demand for water. Cities have become 'Black Holes' for water. Water Bodies were and are intrinsic part of urban areas. They play important role in hydrology, floods and for an important ecological tool (2).

The Comprehensive Development Plan for Coimbatore (CDP 2006) states that only 43 per cent of the households in the city are connected to a sewage system, while the rest either discharge directly into the fresh water ecosystems, the River Noyyal or are connected to individual septic tanks. Industrial and other municipal effluents, much more polluting in terms of their recalcitrant pollutant loads, follow the same path - flow down to the nearest watercourse (3), (4).

Prior to September 2010, the city had nine lakes within the Coimbatore Corporation limits namely Ammankulam, Narasampathy, Krishnampathy, Selvampathy, Kumarasamy, Selvachinthamani, Periyakulam/ Coimbatore Big Tank, Valankulam and Singanallur. However, during the last couple of decades a part of the Ammankulam was encroached by slums and the other part by the State Government to build housing blocks (3).

The following figure1shows the location of Narasampathy, Krishnampathy, Selvampathy, Coimbatore big lake and Valankulam lakes on google earth.

Different issues due to urbanization, climate change, landuse changes, etc could have been taken for the study. Taking too many issues might dilute the purpose of study so, the most critical issues are only analysed here. Prior studies concentrate on study of pollution levels from secondary sources and making conservation plans. This research adopts primary survey being conducted around the lakes to avoid biasness caused without considering public opinion about the lakes.

2. Material and methods This research utilizes both quantitative and qualitative data collection methods to explore current and potential future impacts of urbanization on lakes. The survey used targets households who have access to the lakes. The survey was conducted in stages. The sample size was set as thirty household surveys per lake.

Figure 1. Location of the lakes

The sample survey was conducted using random sampling procedure.

During the first stage, the lakes were selected based on preselected criteria, including location of the lake; multiple uses of the lake water (cooking, washing, etc.); number of users and pollution levels.

During the second stage of this process, households were randomly selected. The head of the family/household was given priority to respond to the questions.

The survey questionnaire was designed to capture relevant data from the selected lakes. This included background information on selected lakes, socio-economic profile of the households and their awareness. It further study the urbanization-related issues through local erceptions on the impacts of urbanization, changes in properties of lakes and associated household livelihoods, current coping measures undertaken and potential adaptation options to mitigate future pollution. Fieldwork findings were also collected. In addition, secondary data (storage capacity, depth and surface area of lakes, WQI parameter permissible values, etc.) from various sources were collected and reviewed. Relevant literature provided further understanding on related concepts and supported data analysis of study findings. Geographic Information System (GIS) is used in this research to store, manipulate, analyze, manage, and present different types of spatial or geographical data. The spatial data is generated on ArcGIS software after conducting surveys and referring Google Earth images. Use of the GIS tool and Google Earth eased this work especially to find out shrinkage and encroachment details around the lakes. Analysis of the issues is done using four methods. Then proposals were formulated and conclusions were drawn. The methodology explained above has been shown in figure 2.

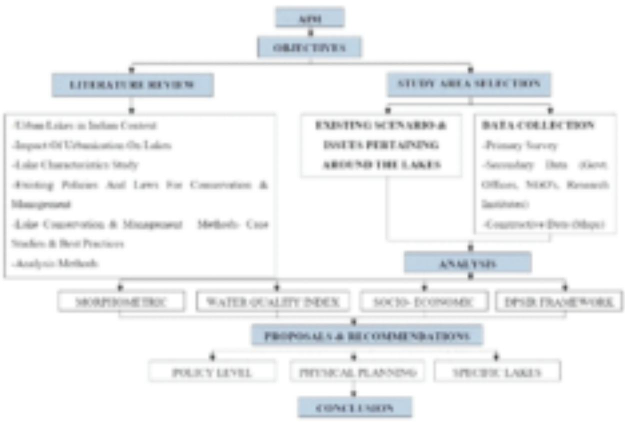

Figure 2. Methodology framework

3. Results and discussion

Conservation of the lakes can significantly enhance the much wanted and rapidly declining. Today all the lakes in and around Coimbatore are highly polluted. In fact, there are alarming signs that lakes and the services they provide us with are being lost at a higher rate than some other ecosystem types. A study reveals that by 2025, 48% of the world will live in water stressed regions. Once these intimate linkages are destroyed, it is rarely possible to restore or recreate them (3).

Morphometric analysis is used to study shrinkage of lakes by means of identifying the changes in the shape and size of a lake system. For this storage capacity, depth and surface area details were analysed. Shrinkage for each lakes was calculated from 2006 (grey) to 2011

(Yellow) and then in 2016 (blue) with the help of google earth. An example has been shown in figure 3. Then encroachment details were drawn out using secondary data (Government or Private encroachments) and google earth images (an example as shown in figure 4). Here, blue color denotes lake area, yellow denotes residential encroachment, green denotes agricultural encroachment and orange denotes other encroachments including institutional, commercial, etc.

Figure 2. Shrinkage of Narasampathy Lake.

Figure 2. Encroachment Near Selvampathy Lake.

For WQI analysis, nine parameters were considered i.e. Turbidity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Nitrate, Temperature, pH, Total Dissolved Solids (TDS), Total phosphate and faecal coliforms. The study analysis revealed that big lakes are most polluted in the area. It was also found out that the lakes where industrial growth is more, are more polluted than the other lakes. Socio-Economic analysis revealed that big lakes are in threatening situation due to high pollution and lack of control regulations from government and people.

DPSIR framework have been made from the literatures and other analysis that has been carried out for this study such as shrinkage details, encroachment details, water quality details, etc. This framework gives us an outline of the problems and how it has affected the lakes.

The literature review discusses the objectives and recognizes the gap in prior studies and further motivates to carry the research. The literature proves that most impacts on lakes are from urbanisation and conservation measures should be decided on relevant planning interventions.

4. Conclusions

This research study is significant for its theoretical and practical contribution. The literature discusses different issues due to urbanization affecting lakes and conservation plans to control those issues. After analysing the issues, proposals hasbeen formulated which may be implemented in the area to avoid or reduce the impact of those issues pertaining in the area. This can be used by the planners and policy makers to monitor current planning practices and identify the problems to take the required conservation and management actions.

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Artificial Neural Network Model for Prediction of Nitrate concentration in groundwater of Kadava River basin

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Abstract

An attempt has been made to develop Artificial Neural Network (ANN) model for prediction of nitrate concentration in groundwater of Kadava River basin, Nashik District, Maharashtra. The study area lies between latitude 19055': 20025'N and longitude 73055:74015'E. River Kadava is one of the tributary of Godavari originates in Sahyadri hills and flows in NW to SE direction. The aim of the study is to develop ANN model to predict the nitrate concentration in groundwater of Kadava River basin. Forty (40) representative groundwater samples were collected from dug/bore wells and analysed for major cations and anions during pre and post monsoon season of 2012. Exploratory statistical techniques were used to identify the nature of the data. Further, ANN model has been proposed and derived for optimization of nitrate concentration. The Levenberg - Marquardt Back Propagation algorithm and three layer back-propagation ANN is employed for the architecture.

Analytical results were compared with the Bureau of Indian Standards (BIS) confirms that, 67.50% and 75% of groundwater samples having NO3 concentration beyond the permissible limit (>45 mg/L) in both the seasons. The consumption of water having high nitrate contents is harmful to human health; consequently, it reduces the oxygen carrying capacity of the blood and in infant causes methemoglobinemia. The optimal ANN model consisting 10 input neurons, 6 hidden neurons and 1 output variable were used for estimation of nitrate concentration. The coefficient of determination (R2), Residual Mean Square Error (RMSE) and Mean Absolute Relative Error (MARE) values shows the efficiency of the ANN model (10-6-1). The spatiotemporal analysis inferred that, nitrate prone areas located in North and Central part of the study area, may be due to intense agriculture/overuse of nitrogen rich fertilizers and natural process viz., dissolution, percolation and leaching. The present model gives satisfactory results for dataset and confirms consistent acceptable performance. The proposed ANN model may be helpful for similar studies. The outcomes of the study will be helpful to local public health bodies and policy makers to develop the strategies.

Keywords: *Groundwater; Nitrate; ANN; Kadava River; Nashik*

An assessment to evaluate the effects of changing climate on glaciers using stable isotopes and remote sensing

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Abstract

Stable water isotope ratios in glacier samples were measured to associate hydro isotopic variation with relative changes in glacierized area.Glacier melt samples (n=50) were collected monthly from six major glaciers of Liddar and Suru basin during melting season from May 2012 November 2013 for $\delta^{18}O$ and $\delta^{2}H$. It was observed that the glacier samples from Suru basin were more depleted in ^{18}O and ^{2}H as well as d-excess. This vital difference in isotopiccharacteristics of glaciers of these two basins suggests two different glacio-hydrological regimes. Highly depleted isotopic value in glacier melt indicates the melting of the glacier even above equilibrium altitude (4000 m). The geospatial observation also revealed that 20% glacier extent (glacierized area) in Liddar basin has been lost in <35 years.

Keywords: Suru, Liddar, stable water isotopes,

1. Introduction

Snow and glaciers, an integral part of the cryosphere, serve as most reliable, sensitive and natural indicators of climate-change due to their proximity of melting condition (Scherler et al., 2011). Temporal changes in the surface/subsurface water flow due to potential effects of climate variability, variation in accumulation and distribution of snow cover is highly uncertain. Accurate monitoring and proper characterization of snow and glaciers are useful for understanding snow/glacier melt processes (Gat, 2010). In the present study the characterization of stable isotopes of water and assessment of climatic effect on water resources was carried out. The study area comprises two glacier dominated basins of the Kashmir and Ladakh region: Liddar basin in Kashmir and Suru basin in Ladakh.

2. Material and methods

Glacier melt samples (n=50) were collected from six major glaciers in Liddar and Suru basin during melting season from May 2012 November 2013 for $\delta^{18}O$ and $\delta^{2}H$. Samples were collected near the snout as melt and solid ice at different altitudes. The samples were sent to Isotope Hydrology Section, Physical Research Lab (PRL), Ahmedabad for the isotopic analysis.Glaciers in Liddar and Suru basin were mapped using multi-temporal optical remote sensing data from the Landsat series.

3. Results and discussion

The $\delta^{18}O$ and $\delta^{2}H$ of glaciers ranged from -8.2 to -16.2‰ for $\delta^{18}O$ and-52.6 to -115‰ for $\delta^{2}H$ with an average of -11.3‰ and -73.4‰, respectively. The isotopic values of glaciers of the Liddar basin were comparatively depleted than glaciers of the Suru basin. This difference in isotopicvalues of glaciers in these two regions is attributed to their different elevation (Suru basin glaciers: 3500-6000 and Liddar basin glaciers: 3200- 4500m, asl) and climate (Suru: cold-arid and Liddar: temperate) (Fig.3).

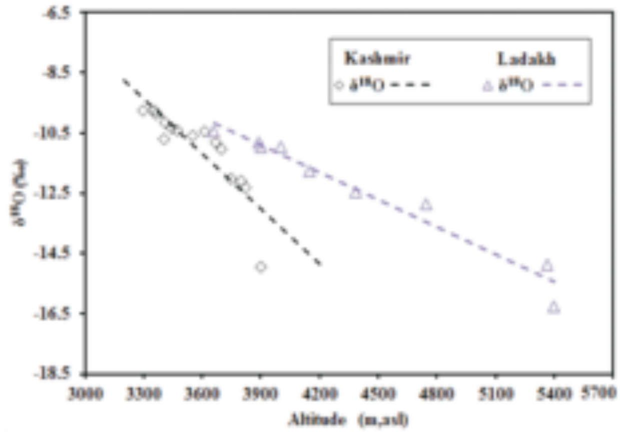

Figure 3 Decrease of $\delta^{18}O$ and $\delta^{2}H$ in glacier melt with increase in altitude in Liddar and Suru basin glaciers

The glaciers in Suru basin exhibited higher correlation (R^2 = 0.96, p = 0.008) than the glaciers of Liddar basin (R^2 = 0.79, p = 0.01). The estimated isotope altitude gradient for the glaciers of Liddar basin varied from -0.55 to -0.68‰ for $\delta^{18}O$ and -3.3 to -5.1‰ for $\delta^{2}H$ per 100 m. The isotope altitude gradient of the glaciers of Suru basin ranges from -0.3 to -0.6 ‰ and-1.4 to -3‰ for $\delta^{18}O$ and $\delta^{2}H$, respectively.

The glaciers showed heavier isotopic values with wide range at the start of the melting season. However, as the summer advanced, depleted isotopic values with narrow range were recorded (Figure 4).

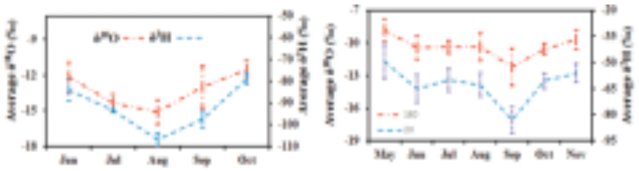

Figure 4 Temporal variation of $\delta^{18}O$ and $\delta^{2}H$ in glacier melt of: (a) Suru and (b) Liddar basin)

The large variability with heavier isotopic values at the start of the melting season (May) reflect the mixed contribution from winter accumulated snow and glacier melt. As the melting season advances the seasonal snow cover is reduced and almost disappears in August/September, which produces the lighter isotopic values.

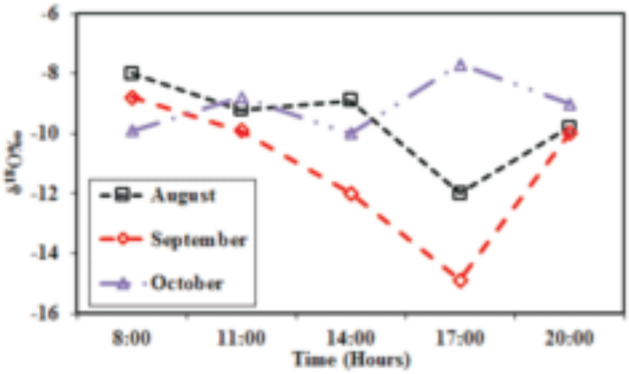

Figure 5 Diurnal variation of isotopic values in glacier meltwater from 8.00 am to 20.00 pm

Overall the isotopic values of glacier melt at snout was heavier in the morning and lighter in the afternoon or evening depending upon the ambient temperature of the day (Fig.5). Highly depleted isotopic values (-14.9 ‰) were observed at the snout of the glacier during sunny days of September is ascribed to be releases probably in the zone of accumulation. This sensitivity of the glaciers to climate variability reveals that the glaciers of the Liddar basin are not the ideal sites for ice coring for paleo-climatological studies.

Deuterium excess of the glaciers

The d-excess values of Suru basin glaciers were lower (13.5 ‰ to 21.6‰) than that of Liddar basin glaciers (17 to 28 ‰) (Figure 6).

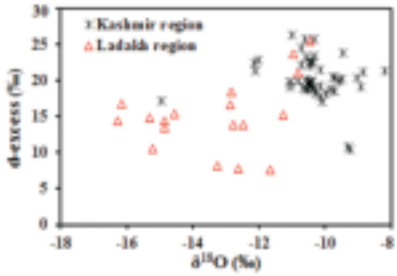

Figure 6 Relationship of $\delta^{18}O$ with d-excess

The lower d values in glaciers of Suru basin could be attributed to the sublimation of snow and glaciers under cold arid climatic condition.

Change in glacier extent and snout position

The results indicate that 11-29 % glacier extent (glacierized area) in Kashmir region has been lost in <35 years. The Kolahoi glacier in Liddar basin exhibits higher retreat than other monitored glaciers. In 1980, the total extent of the Kolahoi glacier was reported as 13.55 km^2, which reduced to 11.18 km^2 in 2015, indicating that 2.37 km^2 of the its extent has been lost from 1980-2015.Similarly, other glaciers in the region have also witnessed significant retreat and decrease in their surficial extent (Sheshram: 0.70 km^2, Hoksar: 0.37 km^2, and Sonsar: 0.31km^2.

4. Conclusion

The depleted isotopic values with lower d-excess of glacier samples in the Suru basin than the glacier samples of the Liddar basin reveals their distinct physiographical and climatological environments.Highly depleted isotopic values observed in the glacier melt during warm and sunny days of September implies that more depleted glacier meltwater is released, probably in the zone of accumulation. It was observed that (20%) Liddar basin glaciers have retreated over the last 35 years. The significantretreat of glaciers, if continue, would have disturbing consequences on the economy of the region.

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Estimation of Re-aeration Coefficient Using MLR for Modelling Water Quality of Rivers in Urban Environment

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Abstract

Re-aeration is the natural phenomenon responsible for the generation of oxygen through the air water interface, advection, dispersion and transient storage reactions. The process of re-aeration, produces the coupling of these equation with the pollutants to generate the harmless products and aids to assimilate pollution load from domestic and industrial waste-water discharges in to river. For the modelling of water quality, re-aeration coefficient is required to be estimated. Study was carried out to estimate the re-aeration coefficient for the Yamuna River. In this study, MLR was used to develop the various models using MATLAB. Developed models were trained, tested and validated using 5 yearlong experimental data. Performance of models were evaluated using Coefficient of determination (R^2), correlation coefficient (R) and root mean square error (RMSE). The study would support the water quality management for urban area by linking the best fit developed model with the water quality models.

Keywords: *Re-aeration; MLR; Advection; Water quality*

1. Introduction

Urban water usage as well as urban water quantity and quality problems is closely linked to the city's development [1]. Maintaining the quality and quantity of urban water resources is recognised as a very complex task including different spatial and temporal scales due to the variation in physical, chemical and biological parameters such as temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total coliform and fecal coliform [2]. River systems are greatly affected by the abstraction of water for the municipal supplies and the discharge of urban wastewater through drains/tributaries during low flow period. Largely biological waste from urban distributed sources joins the river undergo biological and chemical changes using dissolved oxygen. Continuous changes in metabolism of stream [3] is critically depends upon the estimation of re-aeration coefficient, which indicate the exchange of oxygen between air-water interface [4]. Many methods have been developed to measure the re-aeration coefficient: tracer gases [5], empirical formulae based on channel hydraulics [6], the night-time drop of oxygen concentration [7], the time lag between noon and the peak of oxygen concentration [8, 9], among others. The choice of the most appropriate method depends on the type and size of river to be studied, as well as on time and budget constraints. Various researchers dominantly have used predictive equations to measure the re-aeration coefficient [10], whereas large errors were found when applied to the other study areas. MLR is the most widely accepted machine learning method and commonly used in water-related research areas to identify the direct relation between the predictor and response variable.

However, study was carried out with the objective to develop the several models using MLR to estimate the re-aeration coefficient that could be applicable to wide range of study areas and identification of best fit model on the basis of their applicability and performance analysis. The model obtained could be coupled with the water quality model to design the pollution control strategies for the urban water management.

2. Material and methods

The study was carried out in the Delhi-Agra stretch of Yamuna River, which is a major river of Ganga Basin. Physio-chemical test were performed on the 78 samples collected from the different sections of river using standard methods for the examination of water (APHA, 2005). MATLAB have been used to develop the models of MLR to predict the relation between predictor variables and response variables. Re-aeration coefficient is selected as response variables whereas, flow (m^3/s), velocity (m/s), depth (m), slope (1/S), width (m), TOC (mg/l), conductivity S/cm) and suspended solids (mg/l) were selected as predictor variables. Five different models were designed using different combinations of predictor variable to observe the variation in response variable. Statistical evaluation were performed using coefficient correlation (R), coefficient of efficiency (R^2) and root mean square error (RMSE).

$$R = \frac{\sum_{i=1}^{n}\{(K_{Pi} - \bar{K}_P)(K_{Mi} - \bar{K}_M)\}}{(\sum_{i=1}^{n}(K_{Pi} - \bar{K}_P)^2 \sum_{i=1}^{n}(K_{Mi} - \bar{K}_M)^2)}$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(K_{Pi} - K_{Mi})^2}{\sum_{i=1}^{n}(K_{Pi} - \bar{K}_P)^2}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(K_{Pi} - K_{Mi})^2}{n}}$$