ENVIRONMENTAL AND EARTH SCIENCES RESEARCH JOURNAL

ISSN: 2369-5668 (Print), 2369-5676 (Online)
Vol. 3, No. 3, September 2016, pp. 49-52
DOI: 10.18280/eesrj.030401

A publication of IIETA

International Information and Engineering Technology Association
Advancing the World of Information and Engineering

http://www.iieta.org/Journals/EESRJ

Permeability of lake waters for irrigation purposes: a case study of Antiya Taal, Jhansi, India.

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ABSTRACT

Lentic systems irrespective of their rural or urban location are very often subjected to various anthropogenic pressures that enhance the natural senescence process. Antiya Taal, the urban lacustrine base is a valuable sink for diverse pollutants like detergents, municipal waste, heavy metals, fertilizers, nutrients and pesticides that have rendered the lake water unfit for drinking purposes. So the lake water was assessed for its permeability for irrigation purposes and consequently during the present investigation, the lake water was observed to be best suited to the irrigation purposes.

Keywords: Antiya Taal Water, Permeability, Irrigation Purpose.

1. INTRODUCTION

Demotechnic growth vis-à-vis consumerism has increased human intervention into the natural ecological systems that has resulted in cultural eutrophication, which unfortunately has turned out to be the most potent factor in accelerating the natural ageing process of a lake. In fact people are the causative agents of cultural eutrophication which ensure severe enrichment of natural waters by municipal sewage along with agricultural drainage- the premier causes of cultural eutrophication. Ironically, sewage treatment plants settle out and break down particulate matter but discharge the major nutrient load to the receiving water [13]. This discharge of sewage and excesses of fertilizers has imposed an accelerated rate of succession upon many inland waters of the world thereby resulting in their infelicitous senescence. In fact cultural eutrophication has rendered water of most of the water bodies around the world unfit for drinking purposes. So water of such aquatic resources needs to be evaluated for their permeability in irrigation. In fact from agricultural point of view, it is imperative that only good quality of water be used for irrigation [9] as it plays an important role in the management of irrigation and leaching fraction [3]. Moreover irrigation water influences the crop yield by affecting soil characteristics like salinity, soil permeability, toxicity, texture etc [7].

Antiya Taal in the suburbs of Jhansi is subjected to cultural eutrophication (draining detergents, soaps, sewage into the lake, surface run off that washes away nutrients from the cremation ground, faecal matter, fertilizers, pesticides, soil from the catchment area into the domain of the lake) by its stakeholders and consequently its waters are not good for potable purposes. So Antiya Taal waters have been evaluated for their use in agricultural practices.

2. MATERIALS AND METHODS

Antiya Taal is located between latitude $25^0 12'$-$25^0 16'$N and longitude $78^0 18'$- $79^0 23'$E. The lake is shallow with an area of 0.030 km^2 and is surrounded by residential houses all sides. The increased anthropogenic activities in the adjacent catchment area caused increased inflow of untreated sewage, municipal solid wastes, nutrients and pesticides from urban dwelling thereby deteriorating the water quality of the lake.

Water sampling was done on an average frequency of once every month at the sampling sites of the lake, from the inlet, periphery and middle of the lake. The water samples were collected in air tight plastic bottles, 15cm below the water surface and 5m away from the lake boundary by using a pole. The plastic bottles were thoroughly cleaned and rinsed 3-4 times with water to be collected and tightly capped immediately after the collection. The different chemical parameters viz., sodium, potassium and conductivity analysed during the present study were estimated while following A.P.H.A. (1985). But the assessment of Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC) and Soluble Sodium Percentage (SSP) was done with the help of the formulae [8-10] viz.

$$SAR = \frac{Na^{++}}{\sqrt{Ca + Mg/2}}$$

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

$$SSP = \frac{(Na + K)\,100}{Ca + Mg + Na + K}$$

3. RESULTS AND DISCUSSIONS

For agricultural purposes, chief variables to be evaluated in the classification of water quality [1-5] are:

1. the concentration of dissolved solids and salts;
2. the relative presence of sodium (Sodium Adsorption Ratio);
3. the carbonate and bicarbonate content (Residual Sodium Carbonate);
4. percentage of sodium (SSP); and
5. the concentration of other ions like chlorides.

4. ELECTRICAL CONDUCTIVITY

An electrical conductivity (EC) of up to 700µmohs/cm to 3000 µmohscm^{-1} has slight to moderate effect on plants EC values of more than 3000µmohs/cm will severely affect the crop water availability [3-4]. Water with high salinity is toxic to most plants and poses a salinity hazard. According to the EC value, the waters have been classified as depicted in the table 1.

Table 1. Classification of water on the basis of electrical conductivity

Class	EC value µmohs/cm	Suitability
1	≤250	Excellent
2	250-750	Good
3	750-2000	Permissible
4	2000-3000	Doubtful
5	>3000	Unsuitable

Source: United States Salinity Laboratory (USSL)

Conductivity of water varies directly with the temperature and is proportional to its dissolved mineral matter content. High values of electrical conductivity reflect the presence of higher concentration of total dissolved solids in the form of inorganic salts [11-12]. The prescribed limits of electrical conductivity as per USPH for drinking water is 300µScm^{-1}. Pure water is a poor conductor of electricity. Acids, bases and salts in water make it relatively good conductor of electricity. The important ions that impart conductivity in water are anions Cl-, SO^4-, CO_3, HCO^3- and NO_3- Cations Ca^{2+}, Mg^{2+}, Na^+ and K^+. The variations in the electrical conductivity of the lake water samples from different sites in the Anitya Taal are shown in the Table 2. The values of conductivity in drainage inlets of Anita Taal ranges between 1024 µScm^{-1} and 1950 µmhoscm^{-1} with an average value 1326 µmhoscm^{-1}, Middle of the lake value ranges between 1143 µScm^{-1} and 1558 µmhoscm^{-1} with an average value 1326 µmhoscm^{-1} and periphery of the lake the electrical conductivity lies in between 1087 µScm^1 to 1854 µmhoscm^{-1} with an average value 1249 µmhoscm^{-1} (Table 2) respectively.

Table 2. Water quality of Antiya Lake

Parameters	Antiya Lake		
	Min.	Max.	Average
Drainage Inlet			
EC (µmohscm^{-1})	1024.00	1950	1274.00 ± 88.80
RSC (meql^{-1})	81.35	110.57	95.89 ± 2.59
SAR (meql^{-1})	1.92	15.81	7.94 ± 1.24
SSP (meql^{-1})	23.81	68.86	50.78 ± 4.00
Middle of Lake			
EC (µmohscm^{-1})	1143.00	1558.00	1326.00 ± 62.55
RSC (meql^{-1})	74.40	102.40	90.65 ± 4.84
SAR (meql^{-1})	10.70	11.67	11.24 ± 0.17
SSP (meql^{-1})	63.19	65.52	64.06 ± 0.36
Lake Periphery			
EC (µmhoscm^{-1})	1087.00	1854.00	1249.00 ± 58.76
RSC (meql^{-1})	71.33	134.47	99.53 ± 4.72
SAR (meql^{-1})	4.90	12.29	8.22 ± 0.66
SSP (meql^{-1})	44.56	65.81	57.48 ± 1.96

4. RESIDUAL SODIUM CARBONATE

Residual Sodium Carbonate (RSC) gives an account of calcium and magnesium in the water sample as compared to carbonate and bicarbonate ions (Todd, 1980). Residual Sodium Carbonate content in drainage inlet ranges between 81.35 to 110.57meql^{-1} with an average value of 95.89meql^{-1}, Middle of the lake to be 74.40 to 102.40meql^{-1} with an average value of 90.65meql^{-1} and boundary of lake to be 71.33 to 134.47meql^{-1} with an average value 99.53meql^{-1} (Table 2) respectively. This comparatively increased sodium build up in the waters of Antiya Taal reflect on its deteriorating status with respect to its potable use. Although greater sodium build up has reduced its utility for irrigation purposes as well.

5. SODIUM PERCENTAGE (SSP)

Soluble sodium percentage is thus a measure of sodicity as it indicates the proportion of sodium adsorbed on to the clay mineral surfaces. The minima and maxima of Soluble Sodium Percentage at drainage inlets was found to be 23.81meql^{-1} & 68.86meql^{-1}, at middle of the lake to be 63.19 meql^{-1} & 65.52 meql^{-1} and at periphery of the lake to be 44.56meql^{-1} & 65.81meql^{-1} (Table 2) respectively.

According to Doneen (1954), waters with soluble sodium percentage of <60meq/l belong to very good - good class, with 60–70meq/l belong to good to hazardous class and with >70meq/l belong to hazardous–very hazardous class. In the context of this classification, Antiya Taal waters with SSP values varying from 23.81meq/l to 68.86meq/l fluctuate from very good to hazardous class. So the water of Antiya Taal at each of the three study stations is ideal for irrigation purposes.

6. SODIUM ABSORPTION RATIO (SAR)

Sodium hazard is expressed as SAR. The SAR is calculated from the ratio of sodium to calcium and magnesium. The two later ions play a detrimental role as their presence counts the effect of sodium. The SAR of drainage inlet of Antiya Taal ranges between 1.92 to 15.81meql^{-1} with an average value of 7.94meql^{-1}, Middle of the lake 10.70 to 11.67meql^{-1} with an average value 11.24meql^{-1} and periphery of the lake 4.90 to 12.29meql^{-1} with an average value 8.22meql^{-1} (Table 2) respectively. At the middle of the lake the SAR content is maximum than the inlets and periphery. However the water of Antiya Taal comes under the category of medium hazard as per SAR values.

On the basis of SAR values, US Salinity Laboratory Staff (1954) has classified irrigation water into excellent class (SAR<10 meq/l), good class (SAR=10-18 meq/l), fair class (SAR=18-26 meq/l) and poor class (SAR>26 meq/l). The Antiya Taal waters with SAR values fluctuating from 1.92-15.81meq/l thus vary from excellent to good class. So the waters of Antiya Taal are suitable for irrigation purposes according to USSL (1954) classification.

Correlation matrix reveals that conductivity recorded positive but significant correlation with SAR & SSP and negative correlation with RSC which in turn recorded negative correlation with conductivity, SAR & SSP. SAR revealed positive correlation with conductivity and SSP but negative correlation with RSC. Likewise SSP shared positive correlation conductivity and SAR but negative correlation with RSC.

7. METAL ESTIMATION IN WATER

The data pertaining to the heavy metal analysis of the lake water of Antiya Taal is presented in Table 3. Perusal of the table reveals that that of the seven metals for which Antiya Taal waters were tested, the concentration of the Fe in the lake water was highest during both the summer and winter seasons although it recorded increased values during winter in comparison to summer. As a matter of fact Mn, Ni, Zn & Cu recorded its maximum values during winter. Contrarily Co and Cd increased maximum values during summer in comparison to winter. During winter Fe topped the list in terms of maximum concentration followed by Ni, Mn, Cu, Zn, Co & Cd. However during summer, the hierarchical arrangement of these seven heavy metals in terms of maxima was found to be Fe>Co>Mn>Ni>Zn>Cd>Cu. The table 2 thus is witness that the heavy metals behaved differently during winter and summer seasons. The heavy metal build up in the waters of Antiya Taal owing to immense anthropogenic pressure like sewage (domestic and municipal), faecal matter, fertilizers, detergents, soil, third pollution etc has rendered the water unfit for drinking purposes rather the water of the said lake could thus be used for irrigation purposes.

Table 3. Concentration of heavy metals in water (mgl^{-1})

Metal	Winter			Summer		
	Min	Max	Average	Min	Max	Average
Co	4.27	31.68	15.25	4.82	94.60	36.44
Mn	48.01	77.07	62.99	4.57	54.95	29.14
Ni	20.54	80.18	49.07	20.35	48.25	33.83
Cd	2.56	5.23	3.65	2.56	33.74	10.38
Fe	651.78	678.42	661.47	294.60	417.78	351.42
Zn	10.72	42.75	20.62	11.29	38.64	22.68
Cu	13.45	48.67	26.44	10.25	17.93	13.70

Moreover table 3 also reveals that almost each of these heavy metals recorded seasonal variations (Figure 1). Furthermore the concentration of the Co and Cd was found to increase about double or more times to that of the concentration during the winter thus reducing its palatability. Besides the correlation matrix of the table 3 reveals that Co shares positive but highly significant correlation with Cd & Zn and negative but highly significant correlation with Mn, Ni, Fe & Cu. Similarly Mn recorded positive & highly significant correlation with Ni, Fe & Cu but negative highly significant correlation with Co, Cd & Zn. Ni in turn shared positive highly significant correlation with Mn, Fe & Cu and negative highly significant correlation with Co, Cd & Zn. Cd shares positive highly significant correlation with Co & Zn but negative highly significant correlation with Mn, Ni, Fe & Cu. Fe recorded positive highly significant correlation with Mn, Ni & Co but negative highly significant correlation with Co, Cd & Zn. Likewise Zn record positive highly significant correlation with Co and Cd but negative highly significant correlation with Mn, Ni, Fe & Cu. Similarly Cu shared positive highly significant correlation with Mn, Ni & Fe but negative highly significant correlation with Co, Cd & Zn.

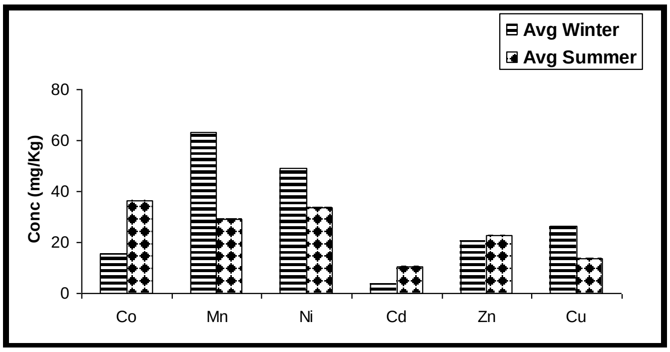

Figure 1. Heavy metals in water during winter and summer

ACKNOWLEDGEMENTS

The authors are thankful to the Himalayan Ecological and Conservation and Research Foundation, J&K and The Department of Environmental Sciences, Bundelkhand University for the laboratory facilities.

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