Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 5, Issue, 07, pp.1744-1751, July, 2013

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

AN APPRAISAL OF UNTREATED AND TREATED WATER IN EASTERN DELHI REGION USING GEOGRAPHIC INFORMATION SCIENCE

Swatantra Kumar Dubey[1], Arnab Kundu[2], Sumit Pal*[3], Vijay Bahadur Yadav[4] and Sajid Ali[5]

[1, 2, 3] Water Technology Centre, Indian Agricultural Research Institute, New Delhi, India
[4] Central Road Research Institute, Delhi-Mathura Road, New Delhi, India
[5]Institute of Environment and Sustainable Development, Banaras Hindu University, Uttar Pradesh, India

ARTICLE INFO

Article History:
Received 23rd April, 2013
Received in revised form
16th May, 2013
Accepted 18th June, 2013
Published online 18th July, 2013

Key words:
Water quality, Untreated water,
Treated water, Yamuna River.

ABSTRACT

From last three decades, industrial revolution in India on boom. And due to this lot of water quality problem arises. Industries are directly drain the effluents in to the water bodies which degrading the water quality and also life. In Delhi region, Yamuna river is the major sink for the industrial drains. In this context, this paper displays a comparative study of untreated water and treated water of Yamuna River for the water quality assessment.

INTRODUCTION

In India, riverine resources contain 113 river basins out of which 14 are majors and remains are minor. (Sharma *et al*., 2009; Sengupta, 2006; Karim and Veizer, 2000; Galy *et al*., 1999; Rengarajan *et al.,* 2009; Sinha *et al.,* 2013). These 14 major river basin accounts for 85% of the total surface flow and 83% of the total area of the basin and contribute and cover 80% of the total length. (Jacob *et al*., 2001; Abbaspour *et al*., 2007; Shiklomanov *et al*., 2003; Amarasinghe *et al*., 2005; Gupta *et al*., 2005; Sharma *et al*., 2009). Due to industrialisation, environmental pollution became a conundrum for human race (Pal, 2011; Taylor, 1996; Friedmann, 2005; Carey, 2007). Lots of research has been carried out by different authors in assessing the water quality profile of rivers using different pollution stress parameters. (Sharma *et al*., 2009; Hamouda *et al*., 2009; Baudrimont *et al*., 1999; Servais *et al*., 2007; Mouillot *et al*., 2006). Yamuna river pollution has been described taking simple parameters viz. Sulphates, fluoride, nitrate, TDS, alkalinity, chloride, total hardness (Singh *et al*., 2012; Tyagi *et al*., 2008; SINGH, 2006; Goel, 2006). The major tool of pollute on profile studies is the water quality index (WQI) (Bordalo *et al*., 2006; Taner *et al*., 2011; Sharma *et al*. 2009; Reza, and Singh, 2010; Lumb *et al*., 2011). An overall index of pollution for surface water based on average value of all the pollution sub indices gives a general classification scheme in the Indian context. (Sargaonkar and Deshpande, 2003; Boyacioglu, 2007; Sharma *et al*., 2009; Alobaidy *et al*., 2010; Sarkar *et al*., 2006; Alobaidy *et al*., 2010; Dede *et al*., 2013). Contamination of drinking water due to exposure to biological and chemical pollutants is a major cause of illness and mortality. (Mokdad *et al*., 2004; Azevedo *et al*., 2002; Pimentel *et al*., 1998; Järup, 2003; Nash, 1993; Metzger *et al*., 1995). The change in pH values of water bodies have been reported to affect aquatic life and alter toxicity of other pollutant in one form or the other (Pal and Vimala, 2012; Federici *et al*., 2007; Novotny, 1995; Ogunfowokan *et al*., 2005; Knutzen, 1981; Cooper, 1993).

Corresponding author: Sumit Pal
Water Technology Centre, Indian Agricultural Research Institute,
New Delhi, India

These chemical compounds and salts present in the river Yamuna are hazardous for the health of humans. (Agrawal *et al*., 2010; Kumar *et al*., 2010; Ohe *et al*., 2004; Gopal, and Agarwal, 2003; Lalwani *et al*. 2005). There are different kinds of diseases triggered by these kinds of chemicals and salts. (Sasahara *et al*., 2007; Morris *et al*., 2008; Baillie-Hamilton, 2005; Joslin, 1849) Sulphates and fluorides are causing various skin irritation and various type of ortho and Neuro diseases. (Simate *et al*., 2012; Murlidhar *et al.,* 2009; Walmsley and Moore, 1999). Nitrates causing blue baby syndromes and skin irritations. (Eneh, 2011; Dorado and Agbisit, 2001; Fisher and Fisher, 2001; Eneh, 2011; Sawian *et al*. 2008). The other factors like TDS, alkalinity, chlorides and total hardness makes the water unfit for drinking and consuming (Asadi *et al*., 2008; Murhekar Gopalkrushna, 2011; Goel, 2006; Singh *et al*., 2003; Manjunatha *et al*., 2012) In developing countries, distribution network has become a point at which contamination frequently occurs to unacceptably high levels, posing a threat to public health. (Vairavamoorthy *et al*. 2007; Vairavamoorthy *et al*., 2007; Srivastava, 2008; Lerner, 2004). In the present research work, the analysis and estimation of sulphates, fluorides, nitrates, TDS, alkalinity, chloride and total hardness have been done of the Yamuna river water near Wazirabad, New Delhi. The work is performed to discuss the suitability of groundwater for human consumption based on the water quality index.

Study Area

Wazirabad is located in the Delhi region (28° 42' 15.5" N; 77° 14' 03.9" E) near Yamuna River. Various types of industrial effluents and agricultural runoffs of Delhi drained in to the Yamuna River in Wazirabad region. The Yamuna River flowing in a southerly direction in the eastern part of the Union Territory of Delhi is the only perennial river in the area. In Wazirabad region, the water treatment plant situated where water has been treated and further distributed in Delhi. But available water treatment facilities are not adequate to remove all the pollutants. Consequently, the Yamuna leaves Delhi as a sewer, laden with the city's biological and chemical wastes. Downstream, at Agra, this becomes the main municipal drinking

water source. Here, too, the existing treatment facilities are inadequate to treat the pollutants. Thus, consumers in Delhi and Agra ingest unknown amounts of toxic pesticide residues each time they drink water (CSE, 2008).Collection of untreated water and treated water of Wazirabad region has done to study the seven parameters that mostly affect the human health. The sample points were indicated through the following map (Figure 1) and overlaid on Land sat TM satellite image which was acquired on 08-05-2011. The image encompassed by blue, green and red bands. In map sampling point 1 are untreated water (SP 1 W RW) and sampling point 2 are treated water (SP 2 W TW) in Wazirabad areas.

1995) and Bureau of Indian Standards (BIS, 1991) which are represented in table. (Table 1)

Table 1. Analytical method used for water quality analysis

Parameter	Analytical method
Total alkalinity	Acid titration method
Total hardness	EDTA titration method
TDS	Total Solids Dried at 103–105°C
Chloride	Argentometric titration method
Sulphate	Spectrophotometric method
Fluoride	SPADNS spectrophotometric method
Nitrate	Spectrophotometric method

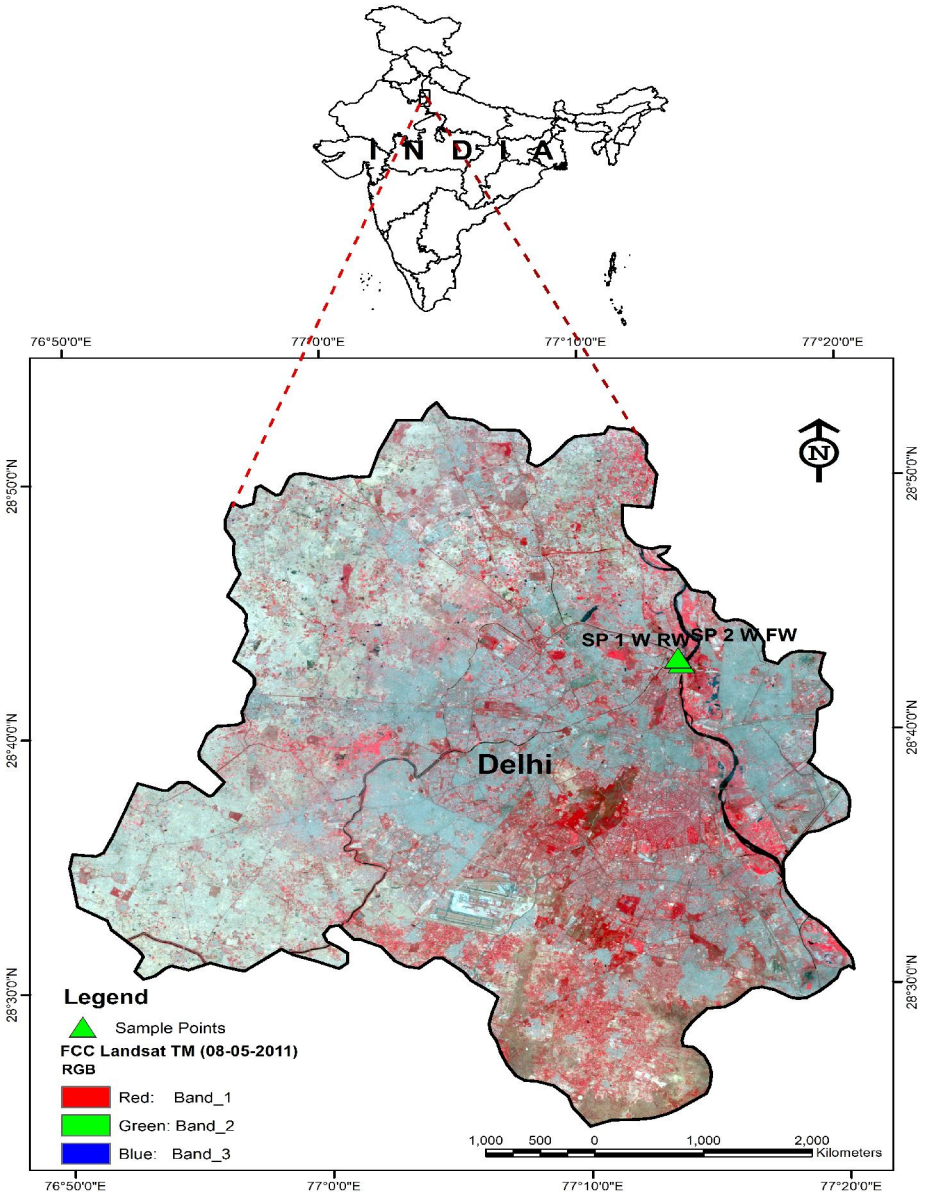

Fig.1. Location map of study site

Note: (SP 1 W RW) Sampling Point-1 Wazirabad untreated water
(SP 2 W TW) Sampling Point-2 Wazirabad treated water

MATERIALS AND METHOD

Untreated water and treated water samples were collected from selected areas up to 9 Months (January 2012 to September 2012) sampling done twice in a month that is supply for drinking purposes. The water samples were collected in pre-cleaned plastic containers. The chemical constituents were analyzed in laboratory using standard methods determined by American Public Health Association (APHA,

In drinking water quality assessment, priority should be given to those substances which are known to be important to health, portability and which are known to be present in significant concentrations in the water source (World Health Organization (WHO), 2006a). The various water quality analyses were carried out following the 20th edition of the Standard Methods for Examination of Water and Wastewater, published by APHA, AWWA, WEF (1998). The Bureaus of Indian Standards (BIS) has published the Drinking Water Quality Specifications (IS-10500:1991) these water quality guidelines

Table 2. Effect of Water Quality Parameters for Drinking Purpose

Parameters	Prescribed limits IS:10500, 1991		Probable effects
	Desirable limits	Permissible limit	
Hardness as $CaCO_3$ (mg/L)	300	600	Affects water supply system (scaling), Excessive soap consumption, and calcification of arteries. There is no conclusive proof but it may cause urinary concretions, diseases of kidney or bladder and stomach disorder
Chloride (mg/L)	250	1000	Injurious to some people suffering from diseases of heart or kidneys. Taste, indigestion, corrosion and palatability are affected.
Total Dissolved Solids (mg/L) TDS	500	2000	Palatability decreases and may cause gastro-intestinal irrigation in human may have laxative effect particularly upon transits and corrosion may damage water system.
Sulphate (SO_4) mg/L	200	400	Causes gastro intestinal irrigation along with Mg or Na can have a cathartic effect on users, concentration more than 750 mg/L may have laxative effect along with Magnesium.
Nitrate (NO_3) (mg/L)	45	100	Cause infact methaemoglobinaemia (blue babies) at very high concentration, causes gastric cancer and affects adversely central nervous system and cardiovascular system.
Fluoride (F) (mg/L)	1	1.5	Reduces dental carries, very high concentration may cause crippling skeletal fluorosis.
Alkalinity mg/L $CaCO_3$	200	600	Impart distinctly unpleasant taste may be deleterious to human being in presence of high pH, hardness and total dissolved solids.

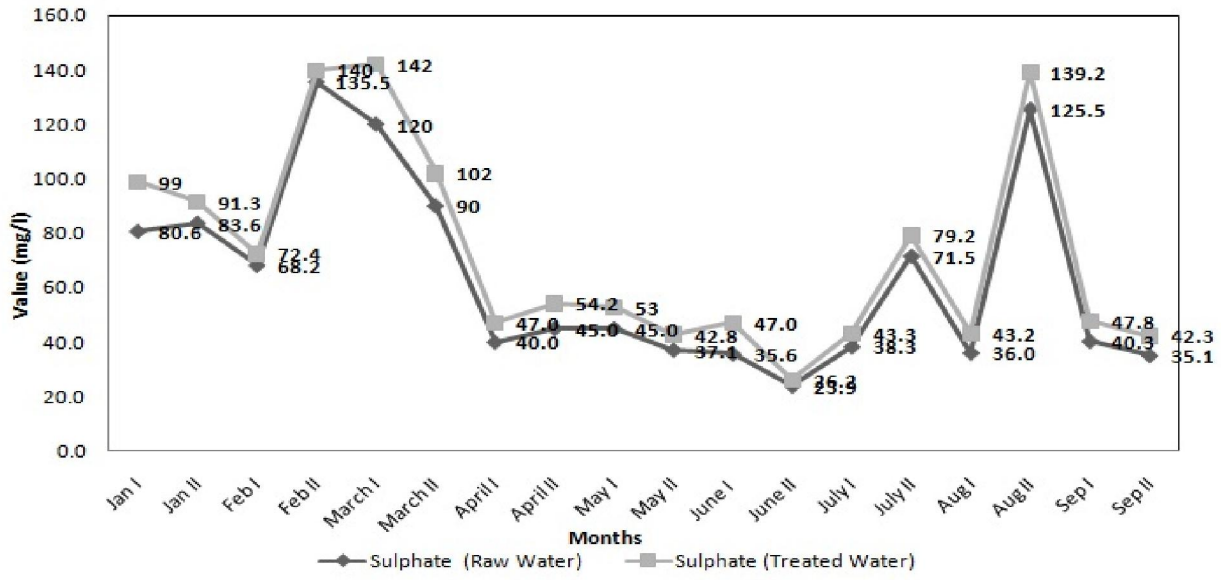

Fig.2. Variation of Sulphate in different months

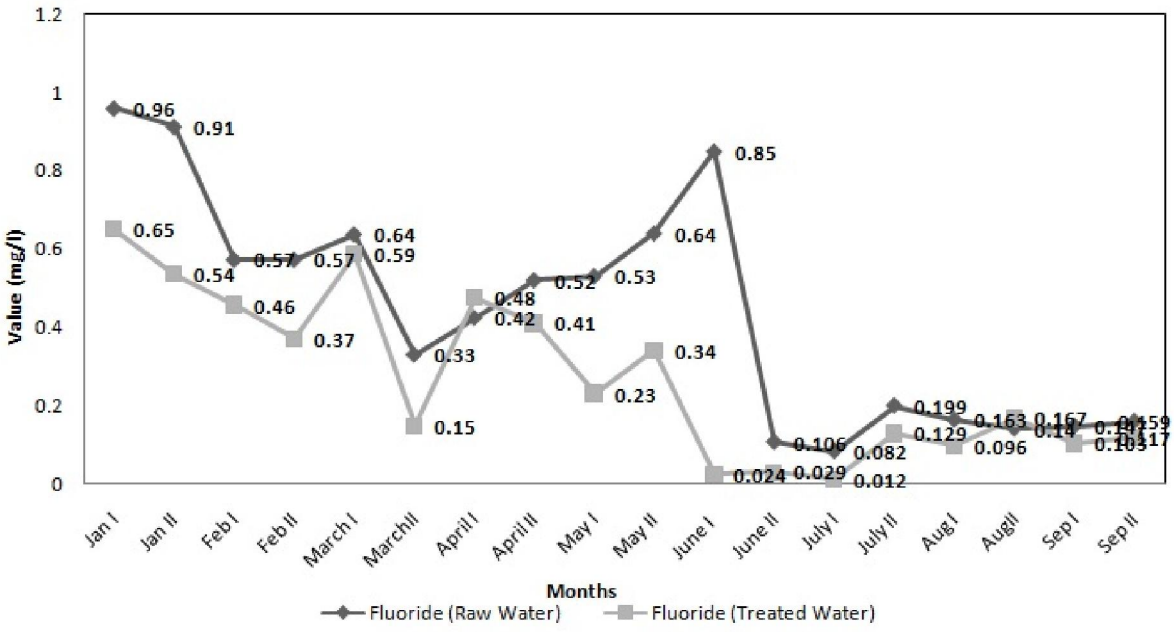

Fig.3. Variation of Fluoride in different months

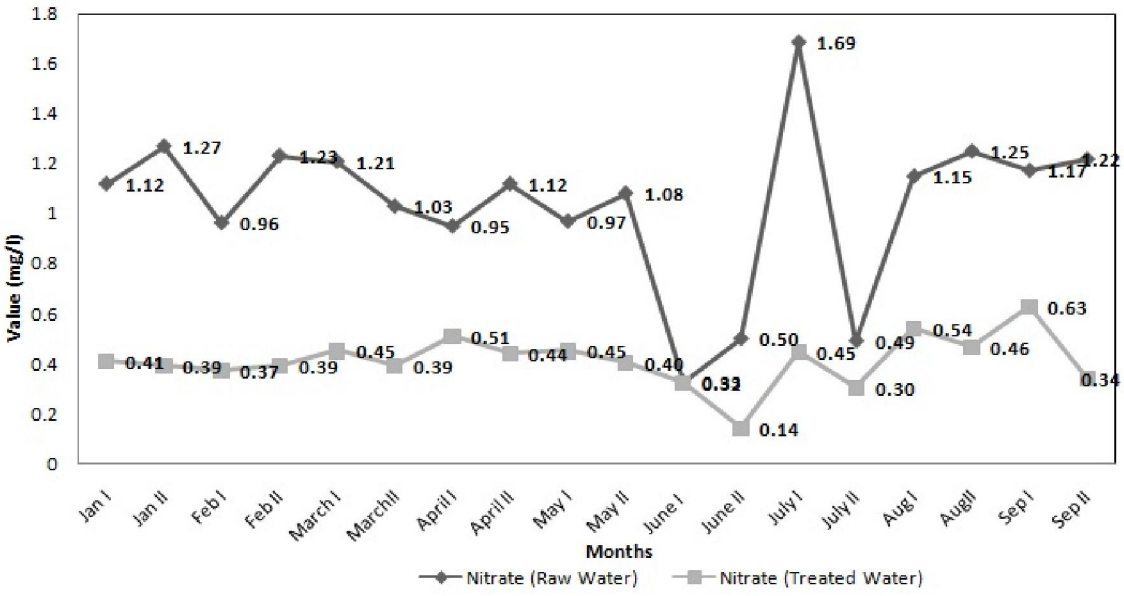

Fig.4. Variation of Nitrate in different months

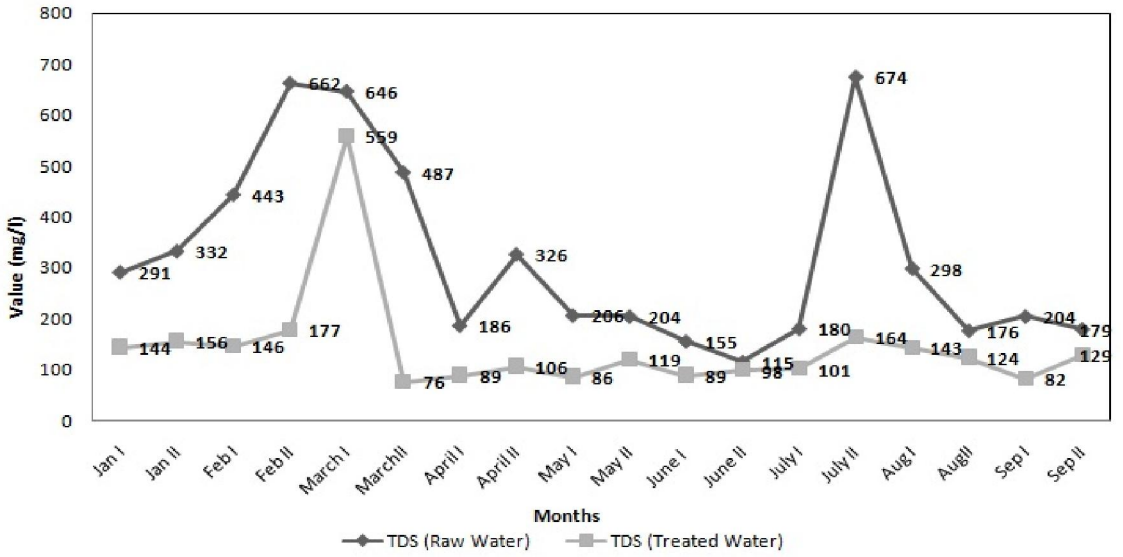

Fig.5. Variation of TDS in different months

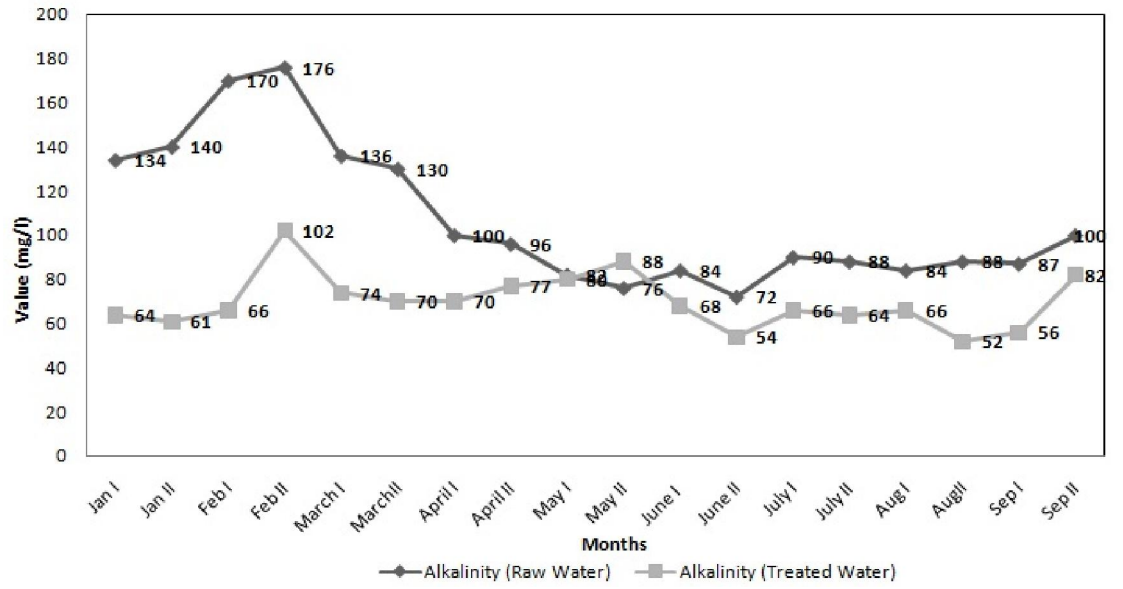

Fig.6. Variation of Alkalinity in different months

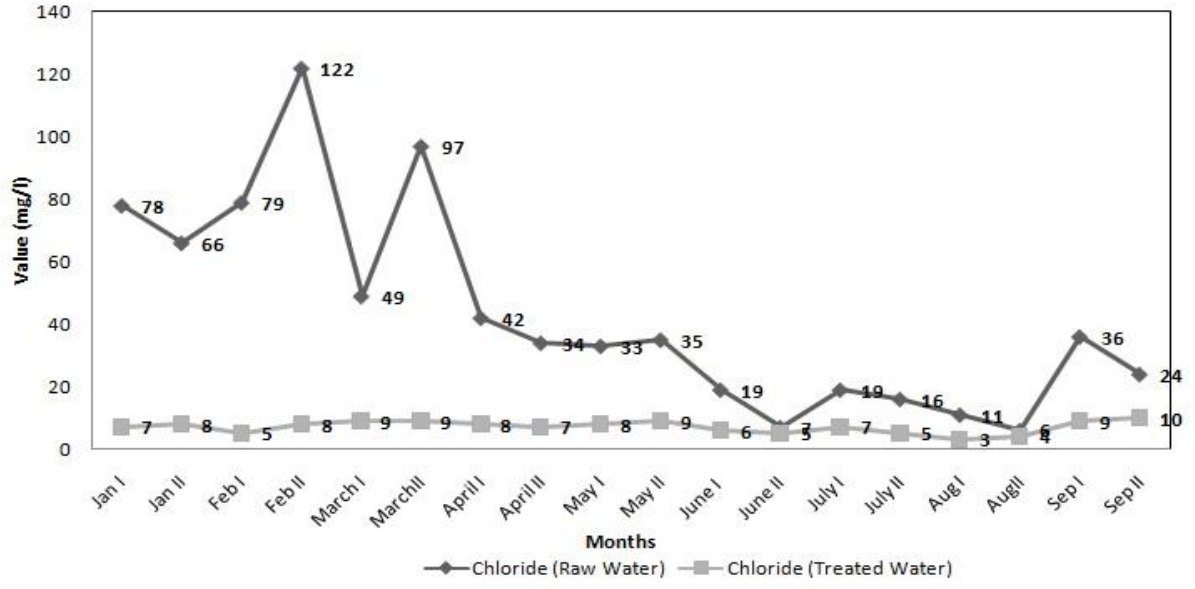

Fig.7. Variation of Chloride in different months

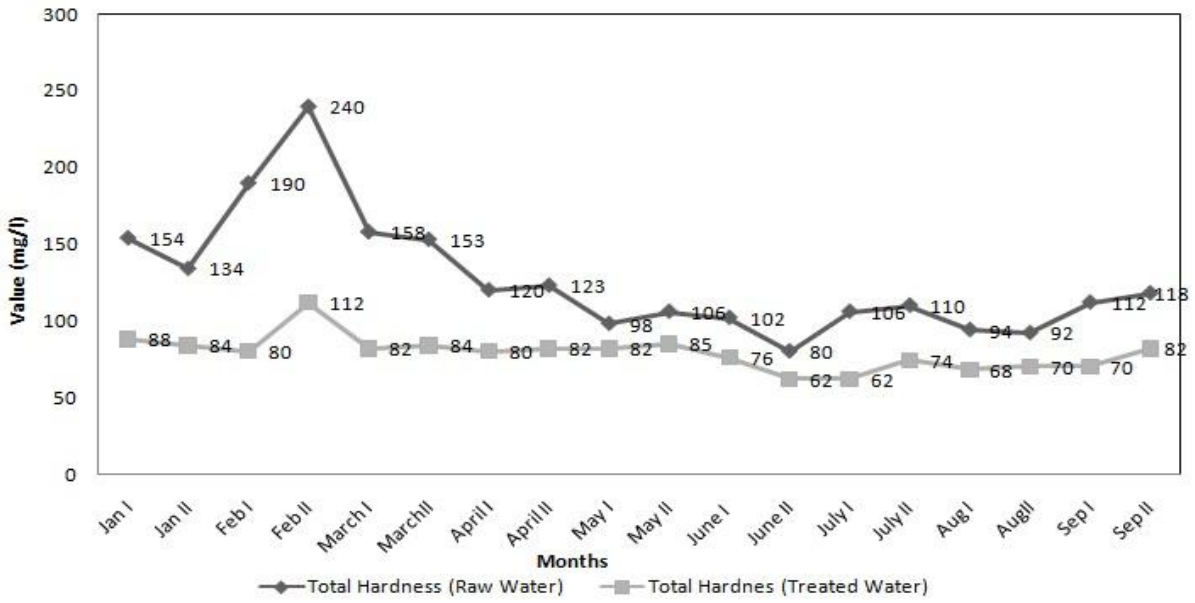

Fig.8. Variation of Total hardness in different months

and specifications have been employed for analysis of results and preliminary assessment of the water quality of river water. The water quality is adjudged based on physical (color, odor, pH, electrical conductivity, turbidity, total dissolved solids, etc.), chemical (chloride, sulphate, carbonate, bicarbonate, nitrate, nitrite, hardness, alkalinity, sodium, potassium, calcium, magnesium, boron, fluoride, iron, manganese, arsenic, copper, mercury, nickel, cadmium, aluminum, chromium, zinc, lead, etc.), bacteriological (total coliforms, fecal coliforms, fecal streptococcus, etc.), biological (DO, BOD, COD, TOC, etc.) and radiological characteristics.

RESULTS AND DISCUSSION

In the study we found that all the parameters were variable in both untreated water and treated water. Figure-2 shows the variation of sulphate in Treated water and untreated water, in treated water sulphate is high in month of February II (140 mg/L) and March I (142mg/L) as compare to untreated water. Sulphate is higher because of mixture of alum for treated of untreated water. In fluoride (Figure-3), it is high in month of January I (0.96 mg/L) and January II (0.91 mg/L) in the untreated water as compare to treated water.

Indian Standard 10500-1991 gives the Desirable limit (1.0 mg/L) and Permissible limit (1.5 mg/L). The important source of nitrate is biological oxidation of organic nitrogenous substances which come in sewage and industrial wastes, domestic sewage contains very high amount of nitrogenous compounds. Figure-4 show the nitrate concentration is high in July I (1.69 mg/L) in untreated water and in treated water concentration of nitrate is lower in June II (0.14 mg/L). Figure-5 show the different between TDS in untreated water and treated water, in untreated water the TDS are high in month of July II (674 mg/L) and also show the higher concentration in February II (662 mg/L) and in treated water the TDS are higher in March I (559 mg/L). TDS denote mainly the various kinds of minerals present in water that is untreated water or treated water. Alkalinity of surface water is primarily a function of carbonate, bicarbonate and hydroxide content. Figure-6 show Alkalinity of untreated water is higher in month of February II (176 mg/L) and in treated water it is also higher in February II (102 mg/L). Chloride is major inorganic anions in water and waste water, the salty taste produced in potable water is due to presence of chloride ions. Figure-7 show the concentration of chloride of untreated water and treated water and chloride are high in month of February II (122 mg/L). Total hardness generally divided by

calcium and magnesium ions i.e. come in water. Figure-8 shows the different concentration of total hardness in different month of untreated water and treated water, in the untreated water the total hardness is higher in the month February II (240 mg/L).

Conclusion

Present study comprises the seven different parameters and it is depicted that the treated and untreated water of Wazirabad region have variations according to the months. In different months, the value of these parameters have changed and also found out higher than the permissible limits (Sulphate 142 mg/l (March); Flouride 0.65 mg/l (January); Nitrate 0.63 mg/l (September); Total Dissolved Solids 559 mg/l (March); Alkalinity 102 mg/l (February); Chloride 10 mg/l (September); Total Hardness 112 mg/l (February). The analysis reveals that the water of the area needs more degree of treatment before consumption and it also needs to be protected from the perils of contamination.

Acknowledgements

The authors express their sincere gratitude to earthexplorer.usgs.gov for providing the Land sat TM satellite image to fulfill this study. We are also thankful to Central Road Research Institute, New Delhi, India for the laboratory experiment.

REFERENCES

Abbaspour, K. C., Yang, J., Maximov, I., Siber, R., Bogner, K., Mieleitner, J., and Srinivasan, R. 2007. Modelling hydrology and water quality in the pre-alpine/alpine Thur watershed using SWAT. Journal of hydrology, 333(2), 413-430.

Agrawal, A., Pandey, R. S., and Sharma, B. 2010. Water pollution with special reference to Pesticide Contamination in India. Journal of Water Resource and Protection, 2(5), 432-448.

Alobaidy, A. H. M. J., Abid, H. S., and Maulood, B. K. 2010. Application of water quality index for assessment of Dokan Lake ecosystem, Kurdistan Region, Iraq. Journal of Water Resource and Protection, 2(9), 792-798.

Alobaidy, A. H. M. J., Maulood, B. K., and Kadhem, A. J. 2010. Evaluating raw and treated water quality of Tigris river within Baghdad by index analysis. Journal of Water Resource and Protection, 2(7), 629-635.

Amarasinghe, U. A., Sharma, B. R., Aloysius, N., Scott, C., Smakhtin, V., De Fraiture, C., and Shukla, A. K. 2005. Spatial variation in water supply and demand across river basins of India (Vol. 83). Iwmi.

APHA 1998. American public health association. Standard methods for examination of waters and wastewaters (20th ed.). Washington, DC: APHA.

Asadi, S. S., Vuppala, P., and Reddy, M. A. 2007. Remote sensing and GIS techniques for evaluation of groundwater quality in Municipal Corporation of Hyderabad (Zone-V), India. International journal of environmental research and public health, 4(1), 45-52.

Azevedo, S. M., Carmichael, W. W., Jochimsen, E. M., Rinehart, K. L., Lau, S., Shaw, G. R., and Eaglesham, G. K. 2002. Human intoxication by microcystins during renal dialysis treatment in Caruaru—Brazil. Toxicology,181, 441-446.

Baillie-Hamilton, P. 2005. Toxic Overload: A Doctor's Plan For Combating The Illnesses Caused By Chemicals In Our Foods, Our Homes And Our Medicine Cabinets. Avery Publishing Group.

Baudrimont, M., Andrès, S., Metivaud, J., Lapaquellerie, Y., Ribeyre, F., Maillet, N. ... and Boudou, A. 1999. Field transplantation of the freshwater bivalve Corbicula fluminea along a polymetallic contamination gradient (River Lot, France): II. Metallothionein response to metal exposure. Environmental toxicology and chemistry, 18(11), 2472-2477.

BIS (Bureau of Indian Standards), Drinking Water Specification (First Revision), IS: 10500: 1991. Bureau of Indian Standards, New Delhi (1991)

BIS (Bureau of Indian Standards), Indian Standard Drinking Water Specifications IS 10500: 1991, Edition 2.2 (2003–09) Bureau of Indian Standards, New Delhi (2003)

Bordalo, A. A., Teixeira, R., and Wiebe, W. J. 2006. A water quality index applied to an international shared river basin: the case of the Douro River. Environmental management, 38(6), 910-920.

Boyacioglu, H. 2007. Development of a water quality index based on a European classification scheme. Water Sa, 33(1).

Carey, M. (2007). The history of ice: how glaciers became an endangered species. Environmental History, 12(3), 497-527.

Cooper, C. M. 1993. Biological effects of agriculturally derived surface water pollutants on aquatic systems—a review. Journal of Environmental Quality,22(3), 402-408.

CSE, River Yamuna, New Delhi: Centre for Science and Environment. URL: www.rainwaterharvesting.org /Crisis/ Riveryamuna. (2008)

Dede, O. T., Telci, I. T., and Aral, M. M. 2013. The Use of Water Quality Index Models for the Evaluation of Surface Water Quality: A Case Study for Kirmir Basin, Ankara, Turkey. Water Quality, Exposure and Health, 1-16.

Eneh, O. C. 2011. Effects of water and sanitation crisis on infants and under-five children in Africa. Journal of Environmental Science and Technology, 4(2), 103-111.

Eneh, O. C. 2011. Effects of Water and Sanitation Crisis on Infants and Under-five Children in Africa.

Federici, G., Shaw, B. J., and Handy, R. D. 2007. Toxicity of titanium dioxide nanoparticles to rainbow trout (< i> Oncorhynchus mykiss</i>): Gill injury, oxidative stress, and other physiological effects. Aquatic Toxicology, 84(4), 415-430.

Fish, K. The Thirst for Safe Water: Microbial pathogens in water distribution systems.

Fisher, D. E., and Fisher, M. J. 2001. The nitrogen bomb. Discover, 22(4), 50-57.

Friedmann, H. 2005. From colonialism to green capitalism: Social movements and emergence of food regimes. Research in rural sociology and development, 11, 227-264.

Galy, A., and France-Lanord, C. 1999. Weathering processes in the Ganges–Brahmaputra basin and the riverine alkalinity budget. Chemical Geology, 159(1), 31-60.

Goel, P. K. 2006. Water pollution: causes, effects and control. New Age International.

Goel, P. K. 2006. Water pollution: causes, effects and control. New Age International.

Goldman, L. R., and Torres, E. B. 12.8 Environmental health practice.

Gopal, K., and Agarwal, A. 2003. River Pollution in India and Its Management. APH Publishing.

Gupta, H., and Chakrapani, G. J. 2005. Temporal and spatial variations in water flow and sediment load in Narmada River Basin, India: natural and man-made factors. Environmental Geology, 48(4-5), 579-589.

Hamouda, M. A., El-Din, M. M. N., and Moursy, F. I. 2009. Vulnerability assessment of water resources systems in the Eastern Nile Basin. Water resources management, 23(13), 2697-2725.

Holmes Jr, L., and Thompson, J. 2009. Environmental Sciences in Public Health. Basics of Public Health Core Competencies, 49.

International Development Research Centre (Canada), Economy and Environment Program for Southeast Asia, Dorado, M. A., and Agbisit, E. 2001.Backyard and Commercial Piggeries in the Philippines: Environmental Consequences and Pollution Control Option. Singapore: Economy and Environment Program for Southeast Asia.

Jacob, D. 2001. A note to the simulation of the annual and inter-annual variability of the water budget over the Baltic Sea drainage basin. Meteorology and Atmospheric Physics, 77(1-4), 61-73.

Järup, L. 2003. Hazards of heavy metal contamination. British medical bulletin, 68(1), 167-182.

Joslin, B. F. 1849. Homoeopathic treatment of diarrhoea, dysentery, cholera morbus, and the cholera: With repertories for these diseases. W. Radde.

Karim, A., and Veizer, J. 2000. Weathering processes in the Indus River Basin: implications from riverine carbon, sulfur, oxygen, and strontium isotopes. Chemical Geology, 170(1), 153-177.

Knutzen, J. 1981. Effects of decreased pH on marine organisms. Marine Pollution Bulletin, 12(1), 25-29.

Kumar, A., Bisht, B. S., Joshi, V. D., Singh, A. K., and Talwar, A. 2010. Physical, chemical and bacteriological study of water from rivers of Uttarakhand. Journal of Human Ecology-New Delhi, 32(3), 169.

Lalwani, S., Dogra, T. D., Bhardwaj, D. N., Sharma, R. K., and Murty, O. P. 2005. Efficacy of Filter Plant in Removal of Arsenic from Water of Yamuna River. Indian J Commun Med, 30(4), 140-141.

Lerner, D. N. 2004. Urban groundwater pollution (Vol. 24). Taylor and Francis.

Lumb, A., Sharma, T. C., and Bibeault, J. F. 2011. A review of genesis and evolution of water quality index (WQI) and some future directions. Water Quality, Exposure and Health, 3(1), 11-24.

Manjunatha, H., Thirumala, S., Aravinda, H. B., and Puttaiah, E. T. 2012. Qualitative Analysis of Subsurface Water Quality in Challakere Taluk, Karnataka, India. Journal of Tropical Life Science, 2(2), 44-48.

Metzger, R., Delgado, J. L., and Herrell, R. 1995. Environmental health and Hispanic children. Environmental health perspectives, 103(Suppl 6), 25.

Mokdad, A. H., Marks, J. S., Stroup, D. F., and Gerberding, J. L. 2004. Actual causes of death in the United States, 2000. JAMA: the journal of the American Medical Association, 291(10), 1238-1245.

Morris, A. M., Watzky, M. A., Agar, J. N., and Finke, R. G. 2008. Fitting neurological protein aggregation kinetic data via a 2-step, minimal/“Ockham's razor” model: the Finke-Watzky mechanism of nucleation followed by autocatalytic surface growth. Biochemistry, 47(8), 2413-2427.

Mouillot, D., Spatharis, S., Reizopoulou, S., Laugier, T., Sabetta, L., Basset, A., and Do Chi, T. 2006. Alternatives to taxonomic-based approaches to assess changes in transitional water communities. Aquatic Conservation: Marine and Freshwater Ecosystems, 16(5), 469-482.

Murhekar Gopalkrushna, H. 2011. Assessment of Physico-Chemical Status of Ground Water Samples in Akot city. Res. J. Chem. Sci, 1(4), 117-124.

Murlidhar, V., and Kanhere, M. V. DIAGNOSIS OF OCCUPATIONAL DISEASES.

Nash, L. 1993. Water quality and health. Gleick, P., ed.

Novotny, V. 1995. Diffuse sources of pollution by toxic metals and impact on receiving waters. In Heavy Metals (pp. 33-52). Springer Berlin Heidelberg.

Ogunfowokan, A. O., Okoh, E. K., Adenuga, A. A., and Asubiojo, O. I. 2005. An assessment of the impact of point source pollution from a university sewage treatment oxidation pond on a receiving stream-A preliminary study. Journal of applied sciences, 5(1), 36-43.

Ohe, T., Watanabe, T., and Wakabayashi, K. 2004. Mutagens in surface waters: a review. Mutation Research-Reviews in Mutation Research, 567(2), 109-149.

Pal, S. 2011. Bioremediation of chromium from fortified solutions by Phanerochaete chrysosporium (MTCC 787). Journal of Bioremediation and Biodegradation.

Pal, S., and Vimala, Y. 2012. Bioremediation and decolorization of Distillery effluent by novel Microbial Consortium. European Journal of Experimental Biology, 2(3), 496-504.

Pimentel, D., Tort, M., D'Anna, L., Krawic, A., Berger, J., Rossman, J., and Talbot, J. (1998). Ecology of increasing disease. Bioscience, 48(10), 817-826.

Rengarajan, R., Singh, S. K., Sarin, M. M., and Krishnaswami, S. 2009. Strontium isotopes and major ion chemistry in the Chambal River system, India: Implications to silicate erosion rates of the Ganga. Chemical Geology,260(1), 87-101.

Reza, R., and Singh, G. 2010. Heavy metal contamination and its indexing approach for river water. International Journal of Environmental Science and Technology, 7(4), 785-792.

Sargaonkar, A., and Deshpande, V. 2003. Development of an overall index of pollution for surface water based on a general classification scheme in Indian context. Environmental Monitoring and Assessment, 89(1), 43-67.

Sarkar, C., and Abbasi, S. A. 2006. Qualidex–new software for generating water quality indice. Environmental monitoring and assessment, 119(1-3), 201-231.

Sasahara, K., Yagi, H., Naiki, H., and Goto, Y. 2007. Heat-triggered conversion of protofibrils into mature amyloid fibrils of β2-microglobulin. Biochemistry,46(11), 3286-3293.

Sawian, J. T., Lyndem, F. G., and Jeeva, S. 2008. Water Pollution in Relation to Human Health. Environmental Studies. Atlantic Publishers, New Delhi, 108-124.

Sengupta, S. 2006. Rivers And Riverine Landscape In North East India. Concept Publishing Company.

Servais, P., Billen, G., Goncalves, A., and Garcia-Armisen, T. 2007. Modelling microbiological water quality in the Seine river drainage network: past, present and future situations. Hydrology and earth system sciences discussions, 11(5), 1581-1592.

Sharma, M. P., Singal, S. K., and Patra, S. 2009. Water quality profile of Yamuna river, India. Hydro Nepal: Journal of Water, Energy and Environment, 3, 19-24.

Sharma, M. P., Singal, S. K., and Patra, S. 2009. Water quality profile of Yamuna river, India. Hydro Nepal: Journal of Water, Energy and Environment, 3, 19-24.

Sharma, M. P., Singal, S. K., and Patra, S. 2009. Water quality profile of Yamuna river, India. Hydro Nepal: Journal of Water, Energy and Environment, 3, 19-24.

Sharma, M. P., Singal, S. K., and Patra, S. 2009. Water quality profile of Yamuna river, India. Hydro Nepal: Journal of Water, Energy and Environment, 3, 19-24.

Sharma, M. P., Singal, S. K., and Patra, S. 2009. Water quality profile of Yamuna river, India. Hydro Nepal: Journal of Water, Energy and Environment, 3, 19-24.

Shiklomanov, I. A., and Rodda, J. C. (Eds.). 200). World water resources at the beginning of the twenty-first century (p. 435). Cambridge: Cambridge University Press.

Simate, G. S., Iyuke, S. E., Ndlovu, S., Heydenrych, M., and Walubita, L. F. 2012. Human health effects of residual carbon nanotubes and traditional water treatment chemicals in drinking water. Environment international, 39(1), 38-49.

Singh, S., 2006. Indexing hydro-chemical quality status of water in delhi: a gis cum statistical approach (doctoral dissertation, delhi college of engineering).

Singh, S., Rani, A., Mahajan, R. K., and Walia, T. P. S. 2003. Analysis of uranium and its correlation with some physico-chemical properties of drinking water samples from Amritsar, Punjab. Journal of Environmental Monitoring, 5(6), 917-921.

Singh, V. K., Bikundia, D. S., Sarswat, A., and Mohan, D. 2012. Groundwater quality assessment in the village of Lutfullapur Nawada, Loni, District Ghaziabad, Uttar Pradesh, India. Environmental monitoring and assessment, 184(7), 4473-4488.

Sinha, R., Jain, V., and Tandon, S. K. 2013. River Systems and River Science in India: major drivers and challenges. In Earth System Processes and Disaster Management (pp. 67-90). Springer Berlin Heidelberg.

Srivastava, R. C. 2008. Guidance and Awareness raising materials under new UNEP mercury Programs. Center for Environmental Pollution Monitoring and Mitigation, Nirala Nagar, India.

Taner, M. Ü., Üstün, B., and Erdinçler, A. 2011. A simple tool for the assessment of water quality in polluted lagoon systems: A case study for Küçükçekmece Lagoon, Turkey. Ecological Indicators, 11(2), 749-756.

Taylor, M. 1996. Industrialisation, enterprise power, and environmental change: an exploration of concepts. Environment and Planning A, 28(6), 1035-1051.

Tyagi, P., Chandramouli, V., Lingireddy, S., and Buddhi, D. 2008. Relative performance of artificial neural networks and regression models in predicting missing water quality data. Environmental Engineering Science, 25(5), 657-668.

Vairavamoorthy, K., Yan, J., and Gorantiwar, S. D. 2007. Modelling the risk of contaminant intrusion in water mains. Proceedings of the ICE-Water Management, 160(2), 123-132.

Vairavamoorthy, K., Yan, J., Galgale, H. M., and Gorantiwar, S. D. 2007. IRA-WDS: A GIS-based risk analysis tool for water distribution systems. Environmental Modelling and Software, 22(7), 951-965.

Walmsley, T. A., and Moore, G. A. 1999. Dr PM George, Dr R King, SJ Grant.

WHO (World Health Organization), 2006a. Establishing National Drinking Water Standards. Guidelines for Drinking-water Quality Training Pack. WHO (World Health Organization) http://www.who.int/water_sanitation_health/dwq/S17.pdf (accessed on 25 August 2008).

****