International Journal of Agriculture, Environment and Biotechnology
Citation: IJAEB: 9(4): 467-472 August 2016
DOI Number: 10.5958/2230-732X.2016.00061.9

ENVIRONMENTAL SCIENCE

Water quality index for the assessment of groundwater quality in the Sabour block of Bhagalpur district, Bihar

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Paper No. 464 Received: 10-1-2016 Accepted: 5-8-2016

Abstract

Groundwater samples were collected from the different locations of Sabour block of Bhagalpur district, Bihar to assess the groundwater quality using water quality index (WQI). Based on global positioning system (GPS) 59 groundwater samples were collected from the different sources at different depths. A single mathematical approach was identified using several parameters integrated to represent a single value for evaluating groundwater quality called as WQI. In this study twelve parameters, namely, pH, electrical conductivity (EC), total dissolve salt (TDS), Hardness, calcium ion (Ca^{+2}), magnesium ion (Mg^{+2}), sodium ion (Na^{+}), potassium ion (K^{+}), carbonate ion (CO_3^{-2}), bicarbonate ion (HCO_3^{-}), chloride ion (Cl^{-}) and fluoride ion (F^{-}) were used for calculating WQI. The computed WQI shows that 1.69% of water sample falls in excellent categories and 47.45% falls in the good water category, 27.11% of water samples were found poor as well as approximate 17 % found very poor and remaining 6.77% samples are found unsuitable for drinking purposes as far as drinking standards are concerned.

Highlights

- 49.14% of groundwater samples fall good to excellent water quality status while 6.77% of the samples were unsuitable for drinking purpose in the Sabour block.

Keywords: Groundwater quality, water quality index, water quality status, water contamination, irrigation quality

Fresh groundwater is used for domestic and industrial water supply and irrigation all over the world. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization. Groundwater crisis has been caused by human interventions in natural processes. Pollution of surface and groundwater is a global concern of the day (Verma *et al.* 2015). Besides, discharge of untreated wastewater through bores and leachate from unscientific disposal of solid wastes also contaminates ground water thereby reducing the fresh water resources (Choduhury and Rakshit, 2012). Pumping of groundwater have been many negative effects such as pollution of aquifers, seawater intrusion and so on (Verma and Rakshit, 2012). Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions.

Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source. Water quality of any specific area or specific source can be assessed using physical, chemical and biological parameters (Sirajudeen and Vahith, 2014). The values of these parameters are harmful for human health if they occurred more than defined limits (WHO, 2012; BIS1, 2013). Therefore, the suitability of water sources for human consumption has been described in terms of WQI, which is one of the most effective ways to describe the quality of water. WQI utilizes the water quality data and helps in the modification of the policies, which are formulated by various environmental monitoring agencies.

WQI provides a single value that expresses the overall water quality at a certain locations and time based on several water quality parameters. WQI convert the complex water quality data into information that is understandable and usable by the public (Etim *et al.* 2013). WQI has been successfully applied to assess the quality of groundwater in the recent years due to its serves the understanding of water quality issues by integrating complex data and generating a score that describes water quality status. Horton (1965) has firstly use the concept of WQI then developed by Brown et. al. (1970) and further improved by Deininger (Scottish development department, 1975). The present study was carried out with an objective to assess the groundwater quality in Sabour block of Bhagalpur district using WQI.

Materials and Methods

Study area

The study area is situated between and 25° 07′ 10″ and 25° 18′ 15″ N latitude and 86° 59′ 24″ and 87° 10′ 25″ E longitude and covers almost 114.95 km^2 (Fig. 1). Bhagalpur is situated on the bank of Ganga River, even though most of the people fulfil their need of water from groundwater. The climate is subtropical with an average annual rainfall and evaporation value of about 1300 and 2,100 mm, respectively (average of 30 years). Southwest monsoon (July to September) contributes 80% of total rainfall. The monthly mean temperature ranges from 20 to 45ºC, while the annual mean temperature is 31ºC.

Sampling and analysis

Using GPS fifty nine ground water samples were collected from the dug wells (open well), handpumps, submersible pump and deep tube well in the region during the post monsoon period between November 2012 and January 2013. The groundwater samples were collected in one litre narrow mouth prewashed polyethylene bottles. The physico-chemical parameters, namely, pH, EC, TDS, Hardness, Ca^{+2}, Mg^{+2},Na^{+},K^{+}, CO_3^{-2}, HCO_3, Cl^{-} and F^{-} were analysed in the laboratory as per the standard procedure of APHA (1992). WQI was calculated using these twelve physico-chemical parameters (Verma *et al*. 2015) known as standard drinking water quality parameters.

The weighted arithmetic index method (Brown *et. al.* 1970) has been used for the calculation of WQI of the water body. Further, quality rating or sub index (q_n) was calculated using the following equation:

$$qn = 100 \times \frac{(Vn - Vio)}{(Sn - Vio)}$$

(Where, n is the water quality parameters and quality rating or sub index (q_n) corresponding the nth parameters is a number reflecting the relative value of this parameters in the polluted water with respect of this permissible value).

q_n= quality rating for nth water quality parameters

V_n =Estimated value of thenth parameters at a given sampling station.

S_n= Standard permissible value of the nth parameters.

V_{io}= Ideal value of the nth parameters in pure water. (i.e. 0 for all other parameters exceptthe parameters pH and dissolved oxygen (7.0 and 14.y mg/l respectively).

Unit weight was calculated by a value inversely proportional to the standard recommended valve S_n of the corresponding parameters.

$$Kn = \frac{K}{Sn}$$

Kn = unit weight for the nth parameters.

Sn = standard value for the nth parameters.

K = Constant for proportionality.

The overall water quality index was calculated by aggregating the water quality rating with the unit weight linearity:

$$WQI = \frac{qnWn}{Wn}$$

WQI level and water quality status was explained by (Chatterji and Raziuddin 2002) as shown in the table 1.

Fig. 1: Location of map to the sampling site area of Sabour Block, Bhagalpur District

(ref. Verma *et al.* 2015)

Table 1: Represent the Water Quality index (WQI) level and status of water quality

WQI level	water quality status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unsuitable for drinking

Results and Discussion

The physicochemical characteristics of the groundwater were determined and represented in detail by (Verma *et al.* 2015). Using the twelve parameters mentioned above in materials and method, a single mathematical value was calculated called as WQI. The generated score for different locations with latitude and longitude of Sabour block, Bhagalpur district along with water quality status has been shown in the Table 2. The computed WQI that varied from 15.99 to 121.58. The minimum value was obtained for Lailak and maximum for Mirachak. The result indicated that at some of the locations where WQI values obtained were low (<100) are safe for human consumption and for other domestic purpose either directly or with some easier and cheaper treatment methods. The locations like Mirachak where WQI value is >100 is very hard and unsuitable for drinking and other domestic purposes. Such water is non-portable.

The computed WQI was further rated with water quality status and was shown location wise of Sabour block in Table 2. Lailak is the only location where water quality status is excellent. Bahadurpur, Mirachak and Jhurkuria are the locations where water quality status is unsuitable for drinking. The other locations are categorized under good, poor and very poor water quality status. Further, distribution of water samples in percentage according to quality basis was reported in Table 3. According to expressed data groundwater may be categorized into 1.69% of water sample falls in excellent categories and 47.45% falls in the good water category, and 27.11% of water samples were

Table 2: Represent sampling locations (latitude and longitude) with their WQI and water quality status

S. No.	Location	Latitude	Longitude	WQI	Water Quality Status
GW1	Ranitalab	25°15′28″ N	87°01′97″ E	37.53	Good
GW2	Ranitalab	25°15′22″ N	87°0198 “ E	39.99	Good
GW3	Ranitalab	25°15′23″ N	87°01′92″ E	37.48	Good
GW4	Bahadurpur	25°15′20″ N	87°01′58″ E	51.82	Poor
GW5	Bahadurpur	25°15′21″ N	87°01′64″ E	41.05	Good
GW6	Chotigopalpur	25°14′98″ N	87°01′15″ E	43.85	Good
GW7	Chotigopalpur	25°14′44″ N	87°00′93″ E	47.71	Good
GW8	Lodipur	25°14′ 24″ N	87°00′32″ E	52.93	Poor
GW9	Lodipur (Khurd)	25°14′ 07″ N	87°00′32″ E	59.87	Poor
GW10	Basantpur	25°13′97″ N	87°00′24″ E	39.06	Good
GW11	Basantpur	25°13′97″ N	87°00′28″ E	36.21	Good
GW12	Bahadurpur	25°14′46″ N	87°01′49″ E	106.55	Unsuitable
GW13	Bahadurpur	25°14′42″ N	87°01′54″ E	102.69	Unsuitable
GW14	Imbrahimpur	25°14′38″ N	87°01′92″ E	81.00	Very Poor
GW15	Sabour	25°15′30″ N	87°02′08″ E	87.24	Very Poor
GW16	Mirachak	25°15′62″ N	87°02′15″ E	121.58	Unsuitable
GW17	Mirachak	25°15′69″ N	87°02′18″ E	84.98	Very Poor
GW18	Mirachak	25°15′71″ N	87°02′02″ E	74.28	Poor
GW19	Fatehpur	25°15′13″ N	87°02′20″ E	87.87	Very Poor
GW20	Fatehpure	25°14′60″ N	87°02′15″ E	66.06	Poor
GW21	Fatehpure	25°14′61″ N	87°02′20″ E	91.14	Very Poor
GW22	Jhurkuria	25°14′68″ N	87°01′90″ E	44.12	Good
GW23	Jhurkuria	25°14′69″ N	87°01′95″ E	106.95	Unsuitable
GW24	Sabour	25°15′19″ N	87°03′27″ E	72.49	Poor
GW25	Babopur	25°15′24″ N	87°02′87″ E	54.83	Poor
GW26	Babopur Mode	25°15′08″ N	87°02′86″ E	64.11	Poor
GW27	Rajandipur	25°14′58″ N	87°03′60″ E	74.13	Poor
GW28	Rajandipur	25°14′95″ N	87°03′26″ E	88.44	Very Poor
GW29	Mamalkh	25°13′17″ N	87°0680″ E	47.98	Good
GW30	Kalighat	25°13′65″ N	87°06′72″ E	42.13	Good
GW31	Kalighat	25°13′63″ N	87°06′72″ E	91.50	Very Poor
GW32	Mamalkh	25°13′48″ N	87°06′68″ E	41.33	Good
GW33	Shankarpur	25°13′08″ N	87°07′40″ E	80.49	Very Poor
GW34	Shankarpur	25°13′15″ N	87°07′53″ E	54.74	Poor

GW35	Shankarpur	25°13′03″ N	87°07′37″ E	44.18	Good
GW36	Shankarpur	25°13′36″ N	87°07′66″ E	41.61	Good
GW37	Afgama	25°13′32″ N	87°09′05″ E	36.18	Good
GW38	Afgama	25°13′48″ N	87°08′93″ E	61.32	Poor
GW39	Afgama	25°13′31″ N	87°08′92″ E	44.18	Good
GW40	Goga	25°13′33″ N	87°06′32″ E	43.31	Good
GW41	Goga	25°12′83″ N	87°06′10″ E	50.05	Good
GW42	Lailak	25°12′77″ N	87°06′33″ E	56.44	Poor
GW43	Lailak	25°12′65″ N	87°06′42″ E	34.43	Good
GW44	Lailak	25°12′09″ N	87°05′93″ E	15.99	Excellent
GW45	Kurpat	25°10′71″ N	87°05′59″ E	40.37	Good
GW46	Parghri	25°10′63″ N	87°05′62″ E	49.48	Good
GW47	Parghri	25°10′48″ N	87°05′68″ E	57.92	Poor
GW48	Ranga	25°09′87″ N	87°05′56″ E	71.27	Poor
GW49	Ranga	25°09′71″ N	87°05′71″ E	63.60	Poor
GW50	Ranga	25°09′72″ N	87°05′62″ E	66.74	Poor
GW51	Alinagar	25°10′87″ N	87°05′48″ E	79.63	Very Poor
GW52	Alinagar	25°10′34″ N	87°05′30″ E	79.91	Very Poor
GW53	Baidnathpur	25°10′52″ N	87°05′48″ E	44.76	Good
GW54	Baidnathpur	25°10′84″ N	87°06′54″ E	31.21	Good
GW55	Baidnathpur	25°10′62″ N	87°06′48″ E	50.49	Good
GW56	Sibaidih	25°11′11″ N	87°05′83″ E	46.73	Good
GW57	Amdar	25°11′52″ N	87°05′51″ E	40.31	Good
GW58	Rajpur	25°13′74″ N	87°03′57″ E	36.43	Good
GW59	Rajpur	25°12′72″ N	87°03′45″ E	36.59	Good

Where, GW = Groundwater

Table 3: Distribution of water samples in percentage according to quality basis.

WQI value	Water quality status	Percentage of studied water sample (%)
0-25	Excellent	1.69
26-50	Good	47.45
51-75	Poor	27.45
76-100	Very poor	17.00
>100	Unsuitable for drinking	6.77

found poor as well as approximate 17% found very poor and 6.77% samples (Bahadurpur and Mirachak exceed the >100) are found unsuitable for drinking purposesregarding to water quality standard. Similar results were reported for different locations by (Etim *et al.* 2013 and Sirajudeen and Abdul Vahith, 2014). Thus, the present study has very clearly brought out that all the samples, based on WQI are maximum found in the portable category and fit for human consumption, and remaining some samples are found unsuitable for drinking purposes.

Conclusion

The computed WQI for different locations of Sabour block, Bhagalpur district shows that except few locations maximum locations have the value <100 which shows that the water quality of the study area is fit for human consumptions directly or treating with easier and cheaper methods. Only few locations (around 7% of the samples) exceeded WQI score >100 the upper limit for drinking water, unsuitable for human consumptions require water safety guard and remediation practices for the reuse of drinking requirement.

Acknowledgements

We extend our thanks to the Directorate of Research, Bihar Agricultural University, Sabour for providing necessaryfacilities for conducting the research work at Sabour

References

APHA (American Public Health Association). 1992. Standard methods of examination of water and water.(18th Edition ed.), Washingation, DC.

BIS (Bureau of Indian Standards). 2013. Specification for drinking water. IS: 10500, New Delhi, India.

Brown, R. M., McClelland, N.I., Deininger, R.A., and Tozer, R. G. 1970. "A water quality index: Do we dare?" *Water & Sewage Works* **117**: 339–343.

Choduhury, M. and Rakshit, A. 2012.Chemical aspects of ground water quality in the shallow aquifers in selected districts of Eastern Uttar Pradesh. *International Journal of Agriculture, Environment and Biotechnology* **5**(4)**:** 345-351.

Etim, E.E., Odoh, R., Itodo, A.U., Umoh, S.D., Lawal, U. 2013. Water quality index for the assessment of water quality from different sources in the Niger Delta Region of Nigeria. *Frontiers in Science* **3**(3): 89-95

Horton, R.K. 1965. An index number system for rating water quality. *Journal-Water Pollution Control Federation* **37**: 300-305.

Scottish Development Department 1975.Towards cleaner water. Edinburgh: HMSO, Report of a River Pollution Survey of Scotland.

Sirajudeen, J. and Abdul Vahith, R. 2014. Applications of water quality index forGroundwater quality assessment on Tamil Nadu and Pondicherry, India. *Journal of Environmental Research and Development* **8**(3): 443-450

Verma D.K., Kumar, S., Mandal, J., Padbhushan, R. 2015. Evaluating quality of groundwatercollected from intensively cropped areas in Sabour block of Bhagalpur district, Bihar, India. *Ecology, Environment and Conservation* **21**: 53-59

Verma, D.K., and Rakshit, A. 2012. Evaluating effects of water withdrawals on chemical aspects of ground water quality in araziline block of Varanasi district, Uttar Pradesh, India *International Journal of Agriculture, Environment and Biotechnology* **5**(4)**:** 353-360.

WHO (World Health Organization). 2012. Guidelines for Drinking-water Quality, Fourth Edition, ISBN 978 92 4 154815 1.