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Original Research Paper

Water Quality Index (WQI) Analysis of the Salinity-Affected Villages from Purna River Basin of Vidarbha Region

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ABSTRACT

Water Quality Index (WQI) based on physicochemical quality of the water of Purna river basin in Akola and Buldhana district of Vidarbha region was carried out during August to November 2007. A total of 260 water samples were analysed for various physical and chemical parameters. The study showed that all water samples were within the standard permissible limit prescribed by WHO and ISI standards for drinking water except salinity, chloride, nitrate, phosphate and conductivity. On the basis of CCME Water Quality Index (WQI) derived from physicochemical studies, the drinking water was 80% safe and 20% unsafe for the drinking and domestic purposes in salinity-affected villages of Vidarbha region.

INTRODUCTION

With beginning of life on the earth, there was no pollution but rapid urbanization and industrialization have culminated into water, air, and land pollution (Hariharan 2007). Today water pollution is the biggest problem for human beings, characterized by deterioration of the water quality as a result of various human activities which makes water unfit for drinking and domestic use purposes. The main sources of water pollution are chemical fertilizers and pesticides getting in an untreated sewage and industrial effluents into rivers and streams running close to the cities and other lowlands. Many dangerous diseases are also caused by the use of polluted water (Garg et al. 2007). The provisions of safe drinking water have central role in reducing the incidence of many water-borne communicable diseases. The diseases associated with contaminated water, however, remain serious public health problems in India (Tambekar & Charan 2004). The common sources of water are wells (open/tube wells) in villages, and various routes such as effluents from different industries, discharge of drainage systems in natural water reservoirs, different human activities (washing, bathing), domestic and municipal waste, etc. may contaminate these natural sources. The tube well water is almost soil-filtered and should be free from bacterial pathogens but still these sources are found to be contaminated with coliforms (Tambekar et al. 2007).

The Ground Water Survey and Development Agency (GSDA), Government of Maharashtra identified 547 salinity-affected villages (136 in Amravati, 318 in Akola and 93 in Buldhana district) of Vidharbha, covering Purna river valley of 4693 sq km. The ground water in these villages is severely affected by salinity and poor quality (Adyalkar 1963, Tambekar et al. 2007). Hence, an attempt was made to carry out systematic investigations of the physicochemical quality and WQI of water from villages to assess its suitability for drinking purpose.

MATERIALS AND METHODS

A total of 260 water samples were collected from salinity-affect villages in Akola and Buldhana

districts of Vidarbha region from various sources such as rivers and lakes (surface water), open wells (shallow groundwater), tube wells and hand pumps (deep groundwater) and public water supply (treated water) during August 2007 to November 2007 in the sterilized bottles using the standard procedure. All the samples were properly labelled indicating the source, time and date of the collection of the water sample. The analysis of various physicochemical parameters such as pH, turbidity, temperature, total dissolved solids, dissolved oxygen, chloride, salinity, phosphate, nitrate and conductivity were carried out by standard methods (APHA 1998).

Calculation of CCME Water Quality Index (CCME WQI) was made by then following formula.

$$\text{CCMEWQI} = 100 - \left[\frac{\sqrt{F_1^{\,2} + F_2^{\,2} + F_3^{\,2}}}{1.732} \right]$$

The divisor 1.732 normalizes values in the range of 0 to 100; the 0 represents poor and 100 represents the excellent water quality. Where F_1, F_2 and F_3 represent scope, frequency and amplitude as under;

$$F_1 = \left[\frac{\text{Number of failed variables}}{\text{Total number of variable}} \right] \times 100$$

F_1 (scope) represents the percentage of variables that do not meet their objectives (failed objectives).

F_2 (frequency) represents the percentage of individuals test that do not meet their objectives (failed test).

$$F_2 = \left[\frac{\text{Number of failed tests}}{\text{Total number of tests}} \right] \times 100$$

F_3 (amplitude) represents the amount by which failed test values do not meet their objectives value. F_3 was calculated in three steps;

The number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective is termed an "excursion" and is expressed as follows, when the test value must not exceed the objective:

$$\textit{excursion} = \left[\frac{\text{Failed Test Value}}{\text{Objective Value}} \right] - 1$$

For the cases in which the test value must not fall bellow the objectives:

$$\textit{excursion} = \left[\frac{\text{Objective Value}}{\text{Failed Test Value}} \right] - 1$$

The collective amount by which individual tests were out of the compliance was calculated by summing the excursion of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives). This variable, referred to as the normalized sum of excursion, or nse, is calculated as:

$$nse = \frac{\sum \text{excursion}}{\text{Total Test}}$$

$$F_3 = \left[\frac{\text{nse}}{0.01\text{nse} + 0.01} \right]$$

F_3 is then calculated by the asymptotic function that scales the normalized sum of the excursion from objectives (nse) to yield a range between 0 and 100.

Depending on WQI, the quality of water was categorized into:

Excellent (CCME-WQI value 95-100): Water quality is protected with virtual absence of threat or impairment; condition very close to natural or pristine levels.

Good (CCME-WQI value 80-94): Water quality is protected with only a minor degree of threat or impairment; condition rarely deport from natural desirable levels.

Fair (CCME, WQI value 65-79): Water quality usually protected, but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.

Marginal (CCME, WQI value 45-64): Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.

Poor (CCME, WQI value 0-44): Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels (CCME 2001).

RESULTS AND DISCUSSION

A total of 250 water samples from various sources from salinity-affected villages of 11 tahsils of Akola and Buldhana districts of Vidharbha were analysed for physicochemical quality and Water Quality Index (WQI) was derived for each tahsil and district. On the basis of various physicochemical parameters each water sample was classified into within permissible limit (WPL), below permissible limit (BPL) and above permissible limit (APL) as prescribed by WHO (1994) (Table 1). The maximum pH of 10 was recorded at Dudhala (Akola tahsil) village (DGW), and minimum pH of 6.5 at Bhamburda (Akot tahsil). All other water samples from rest of the villages showed pH within permissible limit. High pH of water might be responsible for fish kills as it controls the physiological reactions (Vikal & Tyagi 2007). Seasonal variations were observed in atmospheric temperature, maximum temperature was noticed during summer due to dry weather condition. The minimum temperature was recorded during the rainy season. The temperature is an important factor for various chemical and biochemical reactions in water; and solubility of most substances is also largely depends of temperature (Garg et al. 2007). Maximum conductivity of 2510 µmhos/cm was recorded in DG water in Kasli (Akola district), and minimum (103µmhos/cm) in DG water in Nekanampur, Sangrampur. Maximum TDS (1225 mg/L) were recorded in DGW at Kasli (Akola district), and minimum (90mg/L) in SGW at Bhondgaon, Shegaon. Gastro-intestinal irritation is caused due to higher TDS (Garg et al. 2007). Turbidity was determined by visual method with nearly all the samples within permissible limits except the surface water samples.

During the period of investigation, only 19 samples showed DO below permissible limit (5.0 mg/L in DGW at Donwala). Presence of DO in water may be due to direct diffusion from air and photosynthetic activity of autotrophs. The permissible limit for chloride and salinity is 200-600 mg/L, but maximum of 1355 mg/L and 2447 mg/L were recorded in DGW at Hatla, (Akola district),

Table 1: Permissible limit and physiochemical quality of drinking water available in salinity-affected villages of Akola and Buldhana districts of Vidarbha region.

Parameters	Permissible Limit (PL)	Number water samples		
		B PL	WPL	APL
Temperature	-	0	260	0
pH	6.5 - 9.5	0	259	1
Turbidity	5 NTU	241	0	19
TDS	500-1500	179	81	0
Conductivity	300µmhos/cm	150	0	110
D. O.	6.0-9.5	19	241	0
Chloride	200-600	0	190	70
Salinity	200-600	0	85	175
Phosphate	25 (µg/L)	252	0	8
Nitrate	45	250	0	10

Note: All the values are given in mg/L otherwise as stated. BPL: Below permissible limit, WPL: within permissible limit, APL: Above permissible limit

Table 2: Source-wise quality of drinking water in salinity-affected villages based on WQI.

Source	District	Marginal	Fair	Good	Excellent	Total
Surface Water (SW)	Akola	2	2	4	1	9
	Buldhana	0	4	0	0	4
Shallow Groundwater (SGW)	Akola	0	2	7	1	10
	Buldhana	0	2	26	4	32
Deep Groundwater (DGW	Akola	5	19	22	8	54
	Buldhana	0	15	51	9	75
Public Water Supply (PWS)	Akola	0	0	33	34	67
	Buldhana	0	0	8	1	9
Total	Akola	7 (5%)	23 (16%)	66 (47%)	44 (31%)	140
	Buldhana	0 (0%)	21 (15%)	85 (71%)	14 (12%)	120
Total (%)		7 (3%)	44 (16%)	151 (58%)	58 (22%)	260

Table 3: Taluka-wise water quality by WQI.

Districts	Taluka	WQI	Grade
Akola district	Balapur	74	Fair
	Telhara	81.2	Good
	Akola	85	Good
	Murtijapur	85	Good
	Akot	88	Good
Buldhana district	Nandura	80	Good
	Malkapur	83	Good
	J.Jamod	85	Good
	Shegaon	87	Good
	Sangrampur	94	Good

while the minimum (221 mg/L and 399mg/L) in PWS at Gopalkhed (Akola district). The permissible limit for phosphate in water is 25µg/L, and 8 water samples were above the permissible limit. The maximum phosphate was 48 µg/L in SW at Aadal-Khurd and Jalgoan-Jamod, and minimum (5 µg/L) in PW at Aagar, (Akola district). Phosphate is a nutrient and its concentration above normal limit indicates eutrophication (Koshy & Nayar 1999). The maximum nitrate was 63mg/L in the SW at Aadal-Khurd and Jalgaon-Jamod, and minimum (9 mg/L) in SGW at Palodi, Shegaon tahsil. Nitrogen in water (>100mg/L) causes methaemoglobinaemia, particularly in infants up to six months of age, whose main liquid intake is powdered milk made up with tap water. High concentration of nitrate can cause gastric cancer (Garg 2007). On the basis of WQI, out of 260 water samples, 7 (3%) were marginal, 44 (16%) fair, 151 (58%) good, and 68 (22%) excellent. Out of the total, 47% and 71% samples were good and 31% and 12% excellent from Akola and Buldhana districts respectively. None of the water samples from Buldhana district was in marginal category, whereas 5% samples from Akola district were marginal (Table 2).

CCME water quality index of salinity-affected villages from the Purna river basin of Vidarbha region was in the range of 74 (fair) to 94 (good). In the Akola district, CCME water quality index in Akola taluka recorded 85, Akot 88, Murtizapur 85, and Telhara 81 which showed good water quality, whereas only the Balapur recorded 74 with fair water quality. All the water samples in Buldhana district recorded good quality based on CCME water quality index (Table 3).

CONCLUSION

The CCME water quality index indicated that drinking water quality in Purna river basin of Akola and Buldhana districts of Vidarbha region was marginal (3%), fair (17%), good (58%) and excellent (22%) in the year 2007, but high content of chloride, salinity and conductivity in some places made it unsafe for drinking purposes. On the basis of these physicochemical qualities and CCME water quality index (WQI), 80% water was safe and 20% unsafe for drinking purposes in Akola and Buldhana districts of the Vidharbha region in Maharashtra.

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