# Status of Surface Water Quality in River Markanda and its Correlation With Ground Water Quality and Health of the Residents of Shahabad, Kurukshetra, Haryana, India- A Case Study

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## Abstract

Markanda River, a seasonal stream and one of the tributaries of Ghaggar River, enters Ambala district (Haryana) with heavy loads of industrial effluents from the well-known industrial town –Kala Amb (H.P.) along with additions of domestic wastes and agricultural runoff on its way to Shahbad (District Kurukshetra, Haryana). Both surface (SW) and ground water (GW) quality was assessed to check its suitability for human utilization and the role of each pollutant was also assessed for a period of two years. The higher values of $WQI_{(SW)}$ = 199.70 and $WQI_{(GW)}$ = 176.96 shows that the water was not found fit for potable purpose. PI shows that the prime pollutants are Fe, BOD, COD along with EC and TDS, though in lesser role, for SW and GW deterioration. More health discomforts were found among the younger population. Prevalence of kidney stones (62%), abdominal pains, vomiting, diarrhea and nausea (78%), dermatological problems (52%) was found among the respondents. Hypertension (16%) and diabetes (09%) was observable health issues amongst the elderly population. The study, a first of its kind, focused on the assessment of the status of SW and GW in Shahbad and its possible interference with the health of the residents to help the authorities in making strategic and sustainable developmental policies.

**Keywords-** Anthropogenic, WQI, PI, Physiochemical parameters, effluents, pollutants

## Introduction

Water is the vital component of life which is responsible for origin, existence and continuation of life on this planet. Regularly increasing anthropogenic interventions, neglecting attitude of man towards this precious resource along with ongoing natural activities are posing a threat to the continuity of healthy life. Almost all the major rivers of India are facing water quality deterioration (CPCB, 2010). Although the current log phase of our population can only be sustained with high pace development in industrialization, urbanization and adoption of modern approaches of agriculture but the same is bouncing back as depletion of quality and quality of natural resources and introduction of health disasters. The major health issues related to water contaminations by effluents are cholera, tuberculosis, typhoid and diarrhea, allergies, dermatological issues, GIT disturbances etc. (Kashyap et al., 2015).

Water quality depends on multiple factors like variation in precipitation, soil erosion and agricultural runoff, disposal of untreated or partially treated industrial and domestic effluents and leaching of minerals, geochemical characteristics, climatic conditions etc. (Kashyap et al., 2015). Hence both anthropogenic activities and natural processes vitiate surface water as well as ground water and render them unfit for drinking or other purposes (Carpenter S. R. et al., 1998, Jarvie H. P. et.al., 1998). In Indian scenario the prime source of surface water pollution is disposal of untreated sewage (CPCB, Ministry of environment & Forest 2008) and river are the main transporters and distributors of these wastes (Singh *et al.*, 2008).

Numberless attempts have been made to assess the status of water quality and the factors responsible for its deterioration, throughout the length and breadth of India viz., Bhatt and Pathak (1992), Kumar and Shukla (2006), Prakash K. L. et.al (2006), Avvannavar SM et al (2008) Ramakrishanaiah et.al. (2009), Samantary et.al. (2009), Mishra (2011), Khanna D. R. et.al (2013), Kashyap et al., (2015) to reach to some conclusive strategies but the magnification and diversification of the problem seems beyond the range of remedies.

Water Quality Index (WQI), first formulated by Horton (1965), has been found as one of the effective tools to assess the water pollution status and can be used efficiently in the implementation of water quality enhancement programs. WQI can be calculated by 4 commonly used methods namely National Sanitation Foundation Water Quality Index (NSFWQI), Canadian Council of Ministries of the Environment Water Quality Index (CCMEWQI), Oregon Water Quality Index (OWQI) and Weighted Arithmetic Water Quality Index Method (WAWQI).The WAWQI (Brown *et al.,* 1972) method has superiority over others due to integration of multiple parameters as a mathematical equation that rates the condition of water body for human use. The rating scale vary from 0-100 (Chatterji and Raziuddin 2002) where better water quality has lower WQI values. Another approach to assess the role or contribution of a particular water parameter on the overall quality of water is “Pollution index” (PI). (Aboud and Nandini, 2009). PI values classify the pollutant into 5 classes from non-polluting to severely polluting.

In Indian scenario groundwater acts as prime source (85%) of potable water. Urbanization and demographic load of urban areas is depleting the resource, industrialization in peri-urban areas is contaminating it and agriculture of rural areas is sharing this resource for irrigation. Hence the good quality drinking water is becoming nightmare.

Data says more than $1/4^{th}$ of human diseases which can be prevented are due to detrimental conditions of our environment, about 9.1% of diseases and 6.3% of mortalities at global level are due to use of unsafe water, improper sanitation and unhygienic conditions (UNDP, UNCF, WHO-2002). Hence regular monitoring and assessments of environmental parameters are a must to formulate strategic and sustainable developmental policies (Sharma and Chaudhary 2013). Prevalence of more diseases and shorter human expectancy in developing nations than developed ones is due to long term exposure of their people to detrimental industrial waste (WHO 2002, 2003). Human health damage is another yard stick to measure the environmental conditions (Bency et al., 2003).

Keeping the above importance in mind a study was conducted. The study, a first of its kind, focused on in identifying the status of surface and ground water quality in Shahbad, a town on the bank of river Markanda (Haryana) and its interference with the health status of the residents.

**Objectives of the study**

The broad objectives of the study:-

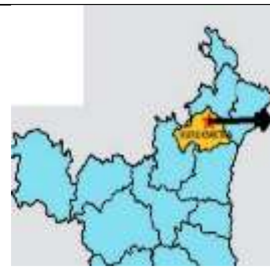
- To assess the water quality of SW in river Markanda (at Shahabad) in terms of WQI
- To assess the water quality of GW near river Markanda (at Shahabad) in terms of WQI
- To assess the PI of individual parameter
- To assess the health status of the residents of Shahbad (on the bank of river Markanda)

## Methodology

### Study area

The sampling station was at 30.1672° N, 76.8684° E coordinates at river Markanda.

**Table no. 1 Location of study area and site:**

- **Water sample collection & analysis**

The surface ($SW_1$-$SW_4$) and ground water samples ($GW_1$-$GW_4$) were collected from above mentioned coordinate's site on yearly basis. Collected samples were analyzed for various physico-chemical parameters (Odour, pH, turbidity, conductivity, TDS chlorides, Fluorides, sulphates, nitrates, Phosphates, Ammonium ions, Fe, Pb, BOD, DO) using standard methods (APHA 2011) within 24 hours, except BOD.

- **Statistical analysis**

1. **Water quality index (WQI):** Weighted Arithmetic Index Method (Brown *et al.*, 1972) has been used for the calculation of WQI for SW and GW samples (Table-1)
2. and results were compared with SW quality status assigned according to Chatterji and Raziuddin (2002) while that of GW according to Singh and Hussian (2016) **Table No. 1- WQI range and water quality rating (Chatterji and Raziuddin 2002* and Singh and Hussian (2016 **)**

**Formula:** $\mathbf{WQI} = \frac{\Sigma Q_n W_n}{\Sigma W_n}$

Where

- $\mathbf{Q_n} = 100 \times \frac{V_n - V_i}{V_s - V_i}$ (quality rating of n[th] water quality parameters)
  - $V_n$ = It's the actual value of n[th] parameters
  - $V_i$ = It's the ideal value of parameters
  - The value of $V_i$= 0 for all parameters except pH($V_i$= 7) and DO($V_i$= 14.6mg/l)
  - $V_s$ = It's the standard permissible value for the n[th] parameters of water quality
- $\mathbf{W_n}$= Unit weight of n[th] parameters.

  $W_n = \frac{k}{V_s}$;

  k= $1/\sum 1/V_s = 1,2,3 \ldots\ldots n$

| WQI level ( SW) | Water quality rating* | Grading | WQI level (GW) | Water quality rating** |
|---|---|---|---|---|
| 0-25 | Excellent | A | < 50 | Excellent |
| 26-50 | Good | B | 50-100 | Good water |
| 51-75 | Poor | C | 100-200 | Poor water |
| 76-100 | Very poor | D | 200-300 | Very poor |
| >100 | Unfit | E | >300 | Unfit for drinking |

### 3. Pollution index (PI)

PI has been used to check the pollution status of individual water parameter which helps to find its contributory role in assessing the water quality (Aboud and Nandani, 2009). It has been calculated as per the formula (Table-2) given by **Amadi (2012**).

**Table No. 2- PI range and water quality rating**

$$PI = \frac{\sqrt{\left[\frac{Ci\ max}{Si}\right]^2 - \left[\frac{Ci\ min}{Si}\right]^2}}{2}$$

Where

- PI = pollution index
- Ci = respective maximum and minimum concentration of quality parameters
- Si = standard permissible limit of surface water quality.

| Class | Value/range | Status |
|---|---|---|
| Class -I | <0.3 | Nonpolluting (NP) |
| Class -II | 0.3-0.5 | Slightly polluting (SP) |
| Class -III | 0.5-1.0 | Moderately polluting (MP) |
| Class -IV | 2-3 | Strongly polluting (St. P) |
| Class -V | >5 | Seriously polluting (Sr. P) |

- **Health data collection & analysis:**

Health data was collected from local residents of Shahabad (different age groups) by personal interviews, using a questionnaire and interaction with local authorities. Total 150 questionnaires were collected from 150 families. Data from complete (135) questionnaires has been incorporated. Health status of people was assessed on the basis of their prevailing symptoms and diseases (reported by them).

## Results & Discussion

(1) In the current study both SW and GW were not found fit for potable use. The GW was found in poor quality rating while SW totally unfit for drinking purpose. The main parameters found beyond permissible range, in SW samples, were Fe, nitrates and BOD while TDS and EC were found to be slightly more when compared with lower permissible ranges. The poor quality GW was found to be due to the very high Fe, nitrate and BOD. Even the maximum values of TDS and EC were also found higher than upper limits of standard values. Almost similar trends have been observed in GW with little lesser values than SW but were found definitely beyond permissible limits. (Table-3) Kushtagi and Srinivas, 2012; Kashyap et al. 2015 also observed that deterioration of the GW quality was due to higher levels of Fe, nitrates, TH, $F^-$, $Cl^-$ , $HCO_3^-$, EC, TDS Na, Ca and Mn.

(2) Higher levels of nitrates in bore well water of Punjab, Haryana and Uttar Pradesh has also been confirmed by scientists of Indian Nitrogen Group (2018) of these the state of Haryana has been found to be in the worst condition (99.5 mg/l). The main reason cited for this was the excessive nitrogenous fertilizer application in the crop fields. Current study support the same finding by observing higher levels of nitrates in GW (85-100 mg/l) as well as SW (87-100 mg/l) against permissible limits of 50 mg/l by WHO. (Table-3)

(3) Central Ground Water Board (CGWB) in 2013 reported the poor status of drinking water in the state of Haryana. According to their report only 11 districts has more than 50% of its potable water

fit for human consumption while 5 has only 30-50% and remaining 5 have even less than 30% potable water. In 2017 the same body declared that the GW in 11 southern districts in Haryana has been found unit for human use and due to higher levels of nitrates and fluoride in it (TOI, 2017). (Table-3)

(4) For higher BOD levels in Markanda River, Haryana state has already blamed the industries of HP, especially those in Kala Amb. (TOI, 2013). The indiscriminate disposal of non and partially treated sewage waste and agricultural runoff are other factors adding to the facts. Present study also support the same findings. BOD, in both SW (20.675±1.639) and GW (18.48±0.420) has been found much higher than permissible limits. Higher COD (11.59±1.188) in SW can be attributed to addition of untreated industrial waste in the river. (Table-3 & 4) Total bacterial count and total fungal count were found 600 cfu/ml & 200 cfu/ml in SW (700 cfu/ml) and GW (<100 cfu/ml). These results support the presence of a large amount of organic waste.

(5) For assessing the purposeful suitability of water, WQI, one of the extensively used tool in India, has been found as one of the best tools to apply as it incorporates the contributory role of many to be parameters and helps squeezing the bulk data into single and simplified value to understand the status of water more clearly. The study showed poor water quality of GW (**WQI= 176.96**) and unfit condition of SW (**WQI= 199.70**) for drinking purposes. (Table-4) Ramakrishnaiah et al. 2009; Sharma and Kansal 2011; Kushtagi and Srinivas, 2012; Tyagi et al, 2013; Sajal and Hussian 2016; Krishna et al. 2016; Acharya et al. 2018, worked on more or less similar parameters of water to check the WQI in different parts of the country and found majority of the surface water bodies in India in moderately or severely unfit conditions, though ground water conditions were found better than SW in some parts.

(6) In the current study, Fe was found as a Sr.P factor while BOD and nitrates as MP factors in the SW **(**Table No.5).Though, the EC and TDS values too were found higher but these variables hold a lower esteem in acting as polluting agents. GW status also showed similar pattern with maximum weightage to Fe, followed by nitrate and BOD. The levels of fluoride were observed as SP agents and EC as MP, as the GW in the state is a source of drinking water. (Table-6) All these support the presence of untreated wastes from all three sectors viz. industry, agriculture and domestic. Impact of pollutants in calculating “PI” has been done by Kashyap et al. 2015 in river Markanda at Kala Amb and has assessed the role of Cr, BOD and COD as strongly polluting agents coming via industrial effluents in it. WHO has reported that 26 out of 718 districts in India has very higher levels of heavy metals in the GW including Fe. (Mohan V, 2018)

(7) Health status under the study showed some significantly alarming situation. Of the sample families, 78% of the families, especially youngsters showed their health discomforts concerning abdominal pains, vomiting, diarrhea and nausea while 52% of the young respondents complained of dermatological problems like skin rashes and lesions. 62% of the female respondents found suffering from renal problems, more specifically renal stones. The elder population did complain of hypertension (16%), diabetes (09%). None of the respondents was found defecating in open areas. 64% of the respondents were having drinking water supply from bore wells and rest (36%) from tap water and these 36% complained the supply of muddy water from their taps and most of these complained about GIT and dermatological issues.

(8) Majority, especially younger population, of the respondents were not satisfied with community cleanliness and the concern of people towards their hygiene levels.. Sharma and Chaudhry (2013) correlated prevalence of asthma, headaches, skin problems, allergies etc. due to introduction of

pollution of different types of industries in Yamuna Nagar, Haryana. Impact of cleanliness and water quality status on the socio-economic system of a nation has also been studied by Kumar and Sharma, 2017. Pal et al., 2018 also pointed out need of importance of regular monitoring of potable water in checking water borne diseases in Indian scenario

(9)

## Conclusion

The present study reveals that the water quality in River Markanda at Sahhbad, is in a poor state. Its surface water is not in a fit state for human consumption. Even the ground water is in a poor quality state. The reasons of this state are higher Fe, BOD and nitrate along with EC and TDS than the permissible limits. Higher Fe content in ground water can be taken as the reason of more prevalence of GIT related health issues among the residents of Shahbad. Higher nitrates, BOD and COD indicate presence of both industrial and organic waste. The study suggests that authorities need to take some strict action against the effluent discharge in surface water and treatment of ground water to make it fit for the consumption of the residents**.**

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**Table No. 3 Mean values and standard deviations of ground and surface water in River Markanda (with standard values given by BIS, WHO and CPCB)**

| **Parameter** | **Surface water (Mean±SD)** | **Standards (BIS#/WHO! /CPCB*)** | **Ground Water (Mean±SD)** | **Standards (BIS#/WHO! /CPCB*)** |
|---|---|---|---|---|
| **pH** | 7.72±0.243 | 6.5- 8.5 | 7.78±0.479 | 6.5- 8.5 |
| **Turbidity (NTU)** | 2.13±0.886 | 5!,* | 0.47±0.0478 | 10 * |
| **Conductivity (µS)** | 840.3±50.934 | 300 **µS** #,!,*<br>(or 0.3 mS/cm) | 755.25±28.998 | 500-800 **µS** #,!,*<br>(or 0.5-0.8 mS/cm) |
| **TDS (ppm)** | 546±33.087 | 500!,*<br>500-1000 # | 490.0±18.860 | 500 * |
| **Sulphates (ppm)** | 62.75±7.932 | 150<br>200-400! | 13.5±1.290 | 200-1000 #,! |
| **Iron (ppm)** | 9.175±0.499 | 0.3-1!* | 9.175±0.280 | 1 * |
| **COD (ppm)** | 11.59±1.188 | 10 !,* | 9.087±0.165 | 20!,* |
| **BOD (ppm)** | 20.675±1.639 | 5 !,* | 18.48±0.420 | 5 !,* |
| **Nitrates (ppm)** | 55.75±5.909 | 45-100 !,* | 92.5±7.593 | 45 !,* |
| **Fluorides (ppm)** | 0.41±0.121 | 1 !,*<br>1-1.5 # | 0.82±0.414 | 1 !<br>1-1.5 # |
| **Chloride (ppm)** | 82.80±6 | 250 !,* | 19.53±0.377 | 250 |

**Table No. 4 Parameters with mean values of surface and ground water of River Markanda and their WQI**

| Parameters | Standards (ICMR/BIS) | Unit weight $W_n$ | Mean value (SW) | Quality rating $Q_n$ (SW) | $Q_nW_n$ (SW) | Mean value (GW) | Quality rating $Q_n$ (GW) | $Q_nW_n$ (GW) |
|---|---|---|---|---|---|---|---|---|
| **pH** | 8.5 | 0.215 | 7.785 | 47.36 | 10.18 | 7.72 | 52 | 11.18 |
| **Turbidity (NTU)** | 5 | 0.0421 | 0.475 | 42.6 | 1.79 | 2.13 | 9.5 | 0.399 |
| **EC µs)** | 300 | 0.0061 | 755.25 | 280.1 | 1.708 | 840.3 | 251.7 | 1.535 |
| **TDS (ppm)** | 500 | 0.00366 | 490.9 | 109.23 | 0.399 | 546.15 | 98.18 | 0.359 |
| **Sulphates (ppm)** | 150 | 0.0122 | 13.5 | 41.83 | 0.510 | 62.75 | 9 | 0.109 |
| **DO (ppm)** | 5 | 0.366 | 6.7 | 100.5 | 36.6 | 4.95 | 82.10 | 30.04 |
| **BOD (ppm)** | 5 | 0.366 | 18.48 | 413.4 | 151.30 | 20.67 | 369.6 | 135.27 |
| **Nitrate (ppm)** | 45 | 0.0412 | 92.5 | 212.77 | 8.766 | 95.75 | 205.55 | 8.46 |
| **Chloride (ppm)** | 250 | 0.00732 | 19.53 | 33.12 | 0.242 | 82.80 | 7.81 | 0.057 |
| **Summations of values** | | $\Sigma W_n$=1.059 | | $\Sigma Q_n$= 1280.91 | $\Sigma Q_nW_n$= 211.49 | | $\Sigma Q_n$= 1085.44 | $\Sigma Q_nW_n$= 187.40 |
| **WQI** | | | **SW= 199.70** | | | **GW= 176.96** | | |

**Table No. 5 Pollution Index of Surface Water in river Markanda (Sharbad)**

| Parameter **(S.W.)** | Max. value | Min. value | Standard valve | Observed PI | | Status | Standard PI [Amadi ,2012] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | A-category | E-category | | | | |
| pH | 8.08 | 7.56 | 6.5-8.5 | 0.219 NP | 0.167 NP | NP | class-I | <0.3 | Non polluting (NP) |
| Turbidity | 3.4 | 1.5 | 10 | 0.152 NP | | NP | | | |
| EC | 896.3 | 774.3 | 500-800 | 0.451 (SP) | 0.282 NP | NP-SP | class-II | 0.3-0.5 | Slightly polluting (SP) |
| TDS | 582.5 | 503.2 | 500 | 0.293 NP | | NP | | | |
| Sulphates | 71 | 52 | 200-1000 | 0.120 NP | 0.024 NP | NP | class-III | 0.5-1.0 | Moderately polluting (MP) |
| Fluorides | 0.5 | 0.23 | 1 | 0.221 NP | | NP | | | |
| Fe | 9.7 | 8.7 | 1 | 2.145 (St. P) | | St. P | class-IV | 2-3 | Strongly polluting (St. P) |
| COD | 12.8 | 10 | 20 | 0.199 NP | | NP | | | |
| BOD | 23 | 19.2 | 5 | **1.266 MP** | | M P | class-V | >5 | Seriously polluting (Sr. P) |
| Nitrate | 100 | 87 | 45 | **0.548 MP** | | M P | | | |

**Table No. 6 Pollution Index of Ground Water in river Markanda (Sharbad)**

| Parameter **(G.W.)** | Max. value | Min. value | Standard valve | Observed PI | | Status | Standard PI [Amadi ,2012] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | A-category | E-category | | | | |
| pH | 8.2 | 7.25 | 6.5-8.5 | 0.298 NP | 0.223 NP | NP | class-I | <0.3 | Non polluting (NP) |
| Turbidity | 0.51 | 0.48 | 5-10 | 0.017 NP | 0.008 NP | NP | | | |
| EC | 796 | 734 | 300 | **0.517 MP** | | M P | class-II | 0.3-0.5 | Slightly polluting (SP) |
| TDS | 517.4 | 477.1 | 500 | 0.199 NP | | N P | | | |
| Sulphates | 15.1 | 13 | 150 | 0.025 NP | | NP | class-III | 0.5-1.0 | Moderately polluting (MP) |
| Fluorides | 0.9 | 0.0 | 1-1.5 | 0.45 SP | 0.3 NP | NP-SP | | | |
| Fe | 9.4 | 8.8 | 0.3-1 | 5.51 Sr. P | 1.65 St. P | St. P-Sr.P | class-IV | 2-3 | Strongly polluting (St. P) |
| COD | 9.25 | 8.9 | 10 | 0.126 NP | | NP | | | |
| BOD | 19 | 17.98 | 5 | **0.622 MP** | | M P | class-V | >5 | Seriously polluting (Sr. P) |
| Nitrate | 100 | 85 | 45-100 | **0.59 MP** | 0.425 SP | SP-MP | | | |

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