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Study on the groundwater quality of Badnagar block in Ujjain district of Madhya Pradesh, India

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Abstract:

Groundwater quality of Badnagar block was assessed for its suitability for drinking purposes. Various water quality parameters *viz.*, pH, colour, turbidity, conductivity, total dissolved solids, chloride, fluoride, total alkalinity, total hardness, calcium hardness, magnesium hardness, nitrate, total coliform and fecal coliform were measured. Majority of the samples don not comply with Indian as well as WHO standards for most of the water quality parameters measured. Overall water quality was found unsatisfactory for drinking purposes.

Keywords- Groundwater, Badnagar block, Water quality parameters.

Introduction:

Water is the most important in the shaping the land and regulating the climate. It is one of the most important compounds that profoundly influence life (Gorde and Jadhav, 2013). Groundwater is used for domestic and industrial water supply and also for irrigation purposed in 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. According to WHO organisation, about 80% of all the diseases in human beings are caused by water (Kavitha and Elangovan, 2010). Consequently number of cases of water borne diseases has been seen which a cause of health hazards. In India, approximately 62 million people including 6 million children suffer from fluorosis because of consumption of water with high fluoride concentrations. Once the groundwater is contaminated, its quality cannot be restored back easily and device ways and means to protect it. Considering the above aspects an attempt has been made under the present study to assess the various physical and chemical properties of ground water of Badnagar block of Ujjain district of Madhya Pradesh, which is mainly used for drinking and other domestic purposes.

Materials and Method:

Study Area:

Badnagar is a tehsil, a city and a municipality in Ujjain district in the state of Madhya Pradesh. It is situated on the bank of River Chamla at an elevation of 497 m. Badnagar tehsil headquarters is Badnagar town. It belongs to Ujjain division. It is located 45 towards west from district headquarters Ujjain, 244 km from state capital Bhopal towards east and 72 km from Indore. Tehsil is bounded by Badnawar tehsil towards west, Depalpur tehsil towards south, Khachrod tehsil towards north, Ujjain tehsil towards east. Indore city, Ujjain city, Ratlam city and Dhar city are the nearby cities to Badnagar. This block consists of 196 villages and 108 panchayats. Badnagar is in the border of the Ujjain district and Dhar district. Dhar district Badnawat is west towards this place. Base map of Badnagar block is shown in Figure- 1.

Sampling Stations:

During the present study, 10 sampling stations were chosen in Badnagar block (Figure- 2).
Details of all stations with their geographical coordinate are given in Table- 1.

Table- 1: Details of sampling stations located in Badnagar block:

S. No.	Station Code	Village	Location	Latitude	Longitude	Altitude
1	B- 1	**Kuldada**	Kamal Gujrati ke Ghar ke pass	23°9’56.7”N	75°35’30.0”E	447
2	B- 2	**Dangwara**	Ashram Mandir ke pass road	23°5’36.0”N	75°31’53.0”E	438
3	B- 3	**Narsinga**	Middle School, Road Side	23°2’40.9”N	75°31’43.6”E	448
4	B- 4	**Daulatpur**	Old Primary School, Aaganwadi	23°3’24.6”N	75°27’38.5”E	440
5	B- 5	**Dotarari**	Middle School	23°0’29.2”N	75°30’1.1”E	441

6	B- 6	**Akoliya**	Nai Abadi	22°59’10.2”N	75°27’52.3”E	448
7	B- 7	**Takrawada**	Puliya ke pass, Akoliya Road	22°58’49.4”N	75°29’1.4”E	444
8	B- 8	**Takrawada**	Near Kabit Akoliya Road	22°58’53.5”N	75°29’7.8”E	441
9	B- 9	**Kuldada**	Primary School	23°9’53.9”N	75°35’28.7”E	555
10	B- 10	**Bhantalavli**	Primary School	23°0’22.8”N	75°27’32.9”E	439

Water Quality Parameters:

In the present study, 14 parameters of water quality have been analysed which is listed in Table- 2.

Table- 2: Water quality parameters selected for the study:

S. No.	Water Quality Parameters
1.	pH
2.	Colour
3.	Turbidity
4.	Conductivity
5.	Total Dissolved Solids
6.	Chloride
7.	Fluoride
8.	Total Alkalinity
9.	Total Hardness
10.	Calcium Hardness
11.	Magnesium Hardness
12.	Nitrate
13.	Total Coliform
14.	Fecal Coliform

Collection of sample, preservation and analysis:

After the identification and fixing of sampling stations, the water samples were collected from these sampling stations. The samples were collected using standard sample collection techniques of Adoni *et al.*, (1985) and APHA (1998). For the study grab samples were collected from the identified sampling stations. The samples for general analysis were collected in 1lt capacity plastic bottles which were prewashed and free from any contaminants. Before the collection of samples, these sample bottles were rinsed again with the sample being collected. The samples for bacterial analysis were collected in pre-sterilized glass bottles and care was taken to avoid direct contact with the samples and sampling containers to prevent contamination of the samples. Thereafter, the samples were transported to the laboratory for further analysis.

Results and Discussion:

Due to increasing urbanization, surface water is getting over contaminated and more stringent treatments would be required to additional sources for fulfil the requirement water, because the groundwater sources are safe and potable for drinking and other useful purposes of human being. Hence studies of physico-chemical characteristics of underground water to find out whether it is fit for drinking or some other beneficial uses.

pH- It is a measure of how acidic/basic water is. The range is from 0-14, with 7 being neutral. pH less than 7 indicate acidic, whereas pH greater than 7 indicates a basic. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. The standard range of pH is 6.5 to 8.5 given by ISI and WHO. During the study, range of pH varied from 7.0 to 8.6 which were slightly above the standard range (Figure- 3). Similar observation was reported by Pisal and Yadav (2014) for groundwater quality assessment of Bhogavati river basin of Kolhapur district, Maharashtra. Though pH has no direct effect on the human health, all biochemical reactions are sensitive to variation of the pH (Rao *et al.,* 1980).

Colour- Colour in drinking water is usually due to the presence of coloured organic matter (primarily humic and fulvic acids) associated with the humus fraction of soil. It may also result from the contamination of the water source with industrial effluents and may be the first indication of a hazardous situation (WHO, 2006). In the present study, the range of colour varied from 1 to 10 hazen (Figure- 4). According to BIS standard colour concentration in groundwater samples of Badnagar block were found below the permissible limit. Higher values of colour are due to the presence of colour imparting matter. No health-based guideline value is proposed for colour in drinking water (WHO, 2006), however it does make the water unpalatable.

Turbidity- It is caused by murkiness or dirtiness of water and is caused by the presence of suspended or colloidal particles in the water. The groundwater is generally free from turbidity as the water reaches the aquifers get filtered through layers of soil which traps most of the suspended and colloidal particulate matter. The value of turbidity was observed between 0 to 5 NTU (Figure- 5). In general the higher values of turbidity were recorded during monsoon season when the changes of contamination of groundwater are highest due to the increased run-off and its subsequent leaching into the aquifer. This is indicating that groundwater is receiving the particulate matter from the surface.

Conductivity- Electrical conductivity is the measure of water capacity to convey electrical current. It depends upon temperature, concentration and types of ions present (Hem, 1991). In the present study range of conductivity varied from 864 to 2015 µS/cm (Figure- 6). The maximum limit of conductivity in drinking water is prescribed as 1500 µS/cm (WHO, 1983). During the present investigation, it was found above the standard limit which may possibly be credited to high salinity and high mineral content (Sunitha *et al.,* 2014).

Total Dissolved Solids- It is the concentrations of all dissolved minerals in water indicate the general nature of salinity of water. The TDS varied from 527 to 1229 mg/l (Figure- 7) in the present study which were within the limit of BIS and WHO for drinking purpose. The total concentration of dissolved minerals in water is a general indication of the overall suitability of water for many types of uses.

Chloride- Chloride is minor constituent of the earth's crust. In drinking water chloride originates from natural sources, sewage and industrial effluents, urban runoff containing salt and saline intrusion (WHO, 2003). In the present study, the value of chloride fluctuated between 45.96 to 228.77 mg/l (Figure- 8) which were within the permissible limit for drinking water according to BIS. Concentration of chloride upto 250 mg/l are not harmful but is an indication of organic pollution (Shivakumar *et al.*, 2000).

Fluoride- Among the various elements, fluoride is thirteenth in the order of abundance in the earth's crust. It is the most electronegative of all known elements (electronegativity 4.0) (Pauling, 1960) and the most reactive. Range of fluoride varied between 0.15 to 0.88 mg/l in the present study (Figure- 9). It was within the standard limit of BIS. Occurrence of fluorine in groundwater has drawn worldwide attention due to its considerable impact on human physiology (Kundu *et al.,* 2001). Fluoride is small amounts is an essential component for normal mineralization of bones and formation of dental enamel (Wood, 1974).

Total alkalinity- Alkalinity of water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium (Pandey and Pandey, 2012). Bicarbonates represent the major form since they are formed in considerable amount from the action of carbonates upon the basic materials in the soil CPCB (2008). Concentration of total alkalinity fluctuated from 174 to 496 mg/l (Figure- 10). The range of 200 to 600 mg/l has been recommended for drinking water by BIS and present observations were within the limit. The high alkalinity in groundwater samples is due to dissolution of carbonates and bicarbonates from the rocks owing to the high residence time. Alkalinity of drinking water has not been reported to be harmful but generally 100 mg/l is desirable for drinking water (Nirmala *et al.,* 2012).

Total hardness- Calcium and magnesium mostly cause the hardness of water. The total hardness of water may be divided into two types, carbonate and temporary and bi-carbonate or permanent hardness. The hardness produced by the bi-carbonate of calcium and magnesium can be virtually removed by boiling the water and is called temporary hardness. The hardness caused mainly by the sulphates and chlorates of calcium and magnesium cannot be removed by boiling and is called permanent hardness. Total hardness is the sum of the temporary and permanent hardness.

In the present study, value of total hardness varied between 166 to 480 mg/l (Figure- 11), range of calcium hardness between 78 to 323 mg/l (Figure- 12) and magnesium hardness from 60 to 213 mg/l (Figure- 13) respectively. Water that has a hardness of <75mg/l is considered soft. A hardness of 75-150 mg/l is not objectionable for most purposes. Water having more than 150 mg/l hardness, is unsafe. The maximum allowable limit of hardness for drinking purpose is 500 mg/l, and the most desirable limit is 100 mg/l as per the WHO international standard. For total hardness, the most desirable limit is 80-100 mg/l (Freeze and

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Cherry, 1979). In the present study range was beyond the standard limit. Groundwater exceeding the limit of 300 mg/l is considered to be very hard (Sawyer and McCarty, 1967).

Nitrate- Nitrate is present in raw water and mainly it is in form of N_2 compound (of oxidizing state). Nitrate is produced from chemical and fertilizer factories, matters of animals, decline vegetables, domestic and industrial discharge. During the present investigation, range of nitrate fluctuated between 0.83 to 4.96 mg/l (Figure- 14). Indian standard recommended 45 mg/l as desirable limit while 100 mg/l as permissible limit. Nitrate was present in all drinking water samples in groundwater within desirable BIS standard.

Total coliform- During the present investigation at all sampling stations of Bad Nagar block total coliform was absent (Figure- 15).

Fecal coliform- Fecal coliform was also absent at all sampling stations of Bad Nagar block (Figure- 16).

Conclusion:

The purpose of the present study was to understand the groundwater quality of Badnagar block of Ujjain district. The investigation revealed that some parameters are within the standard limits while some are beyond the permissible limit. Hence proper attention should be given to water quality monitoring besides groundwater resource development.

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Appendix for Figures (Maps, Charts and Tables) continues on next page.

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Figure- 1: Based map of the study area

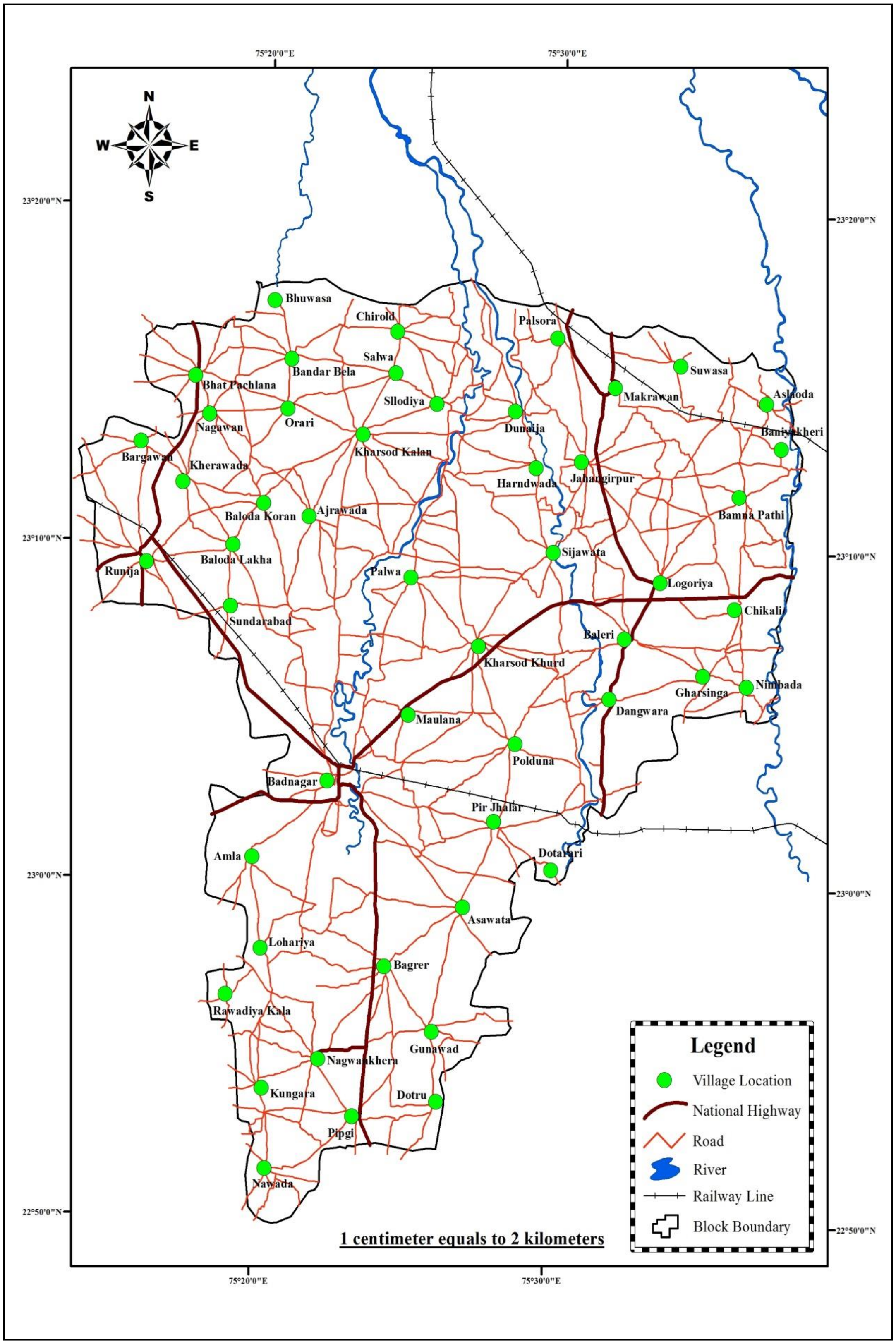

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Figure- 2: Sampling stations of the study area

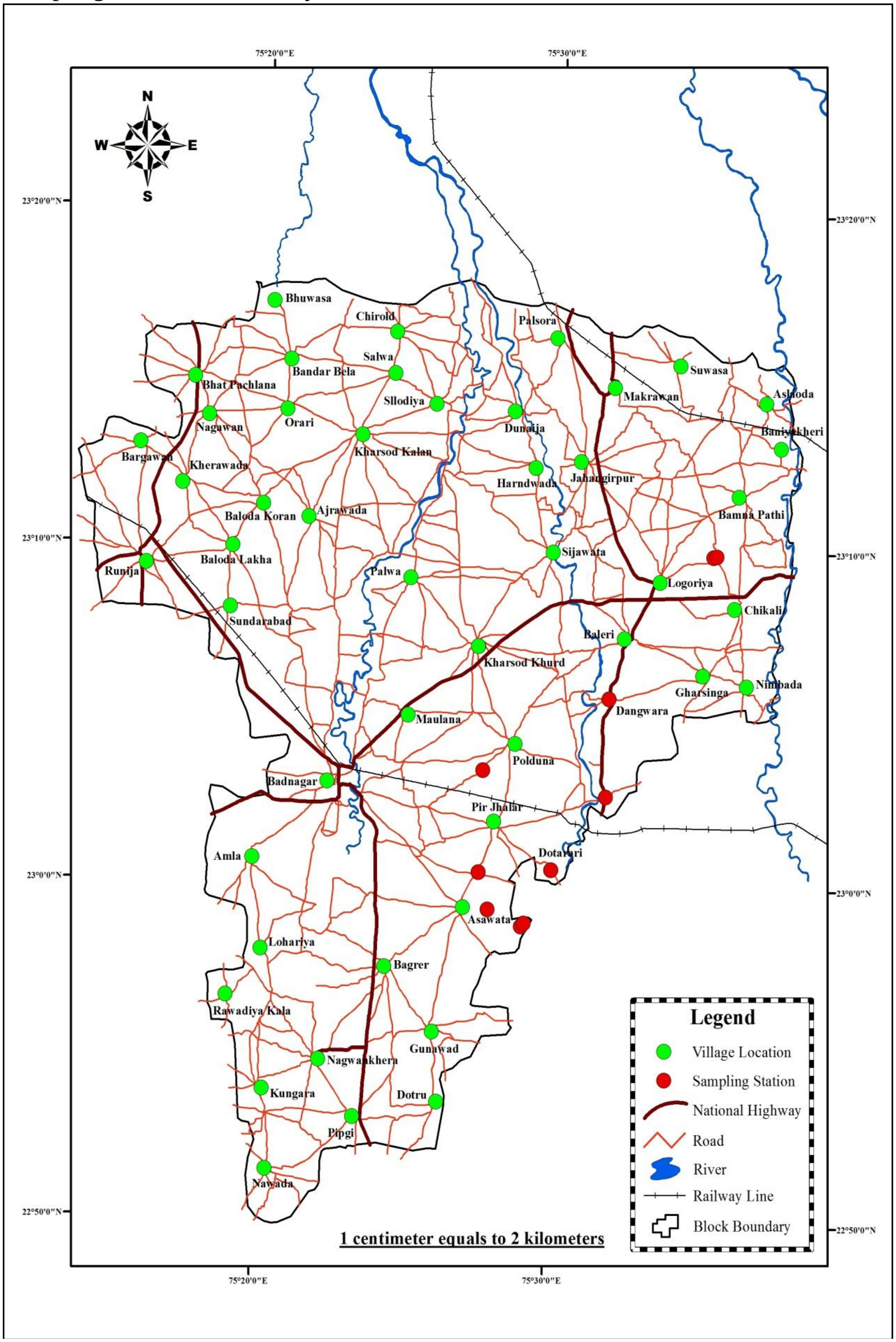

Figure- 3: Seasonal variation in pH at Badnagar block

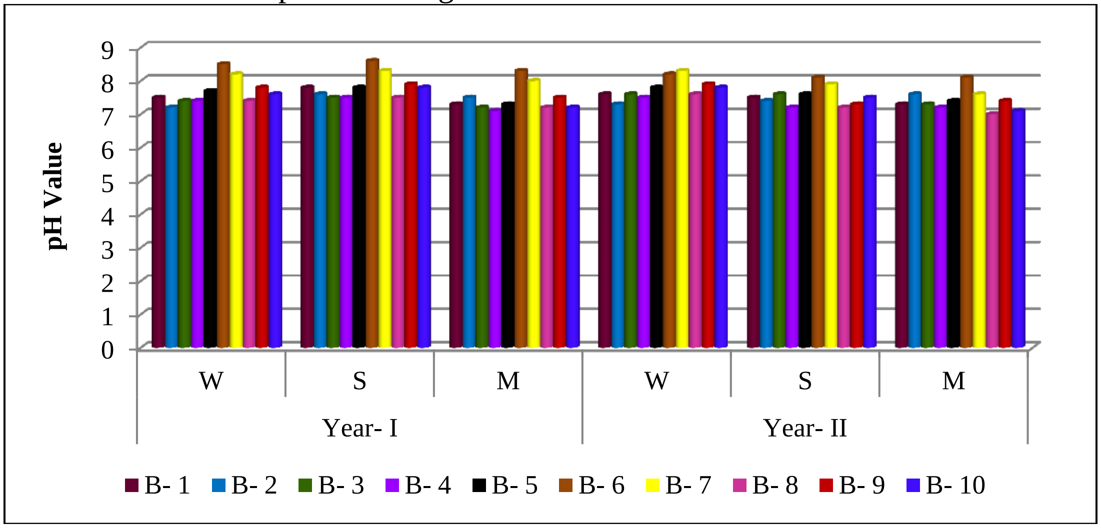

Figure- 4: Seasonal variation in colour at Badnagar block

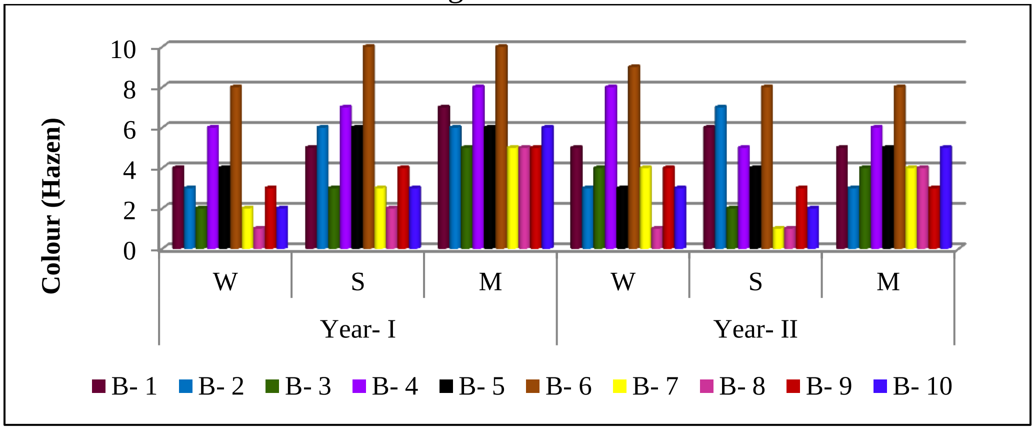

Figure- 5: Seasonal variation in turbidity at Badnagar block

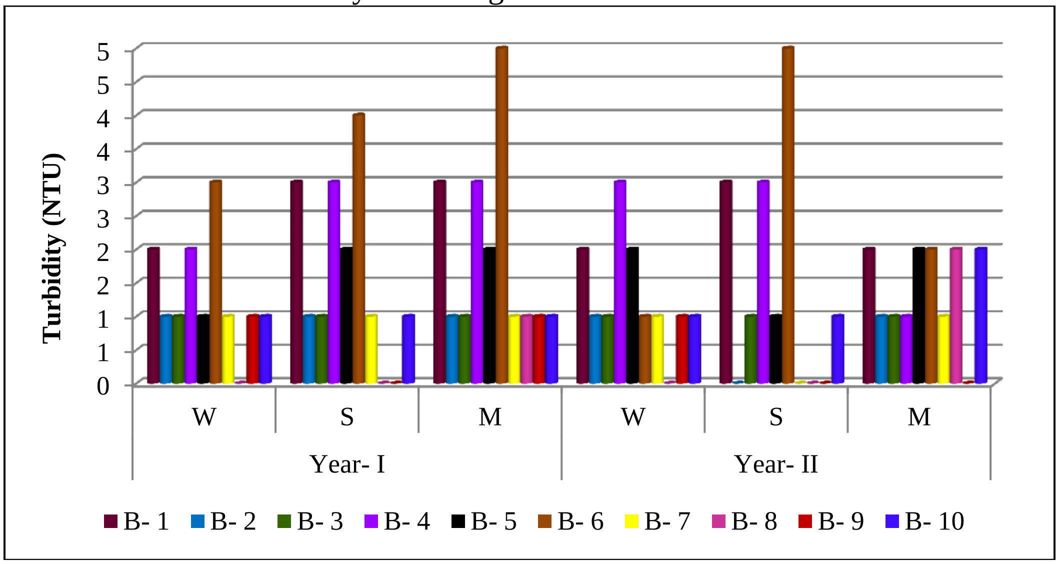

Figure- 6: Seasonal variation in conductivity at Badnagar block

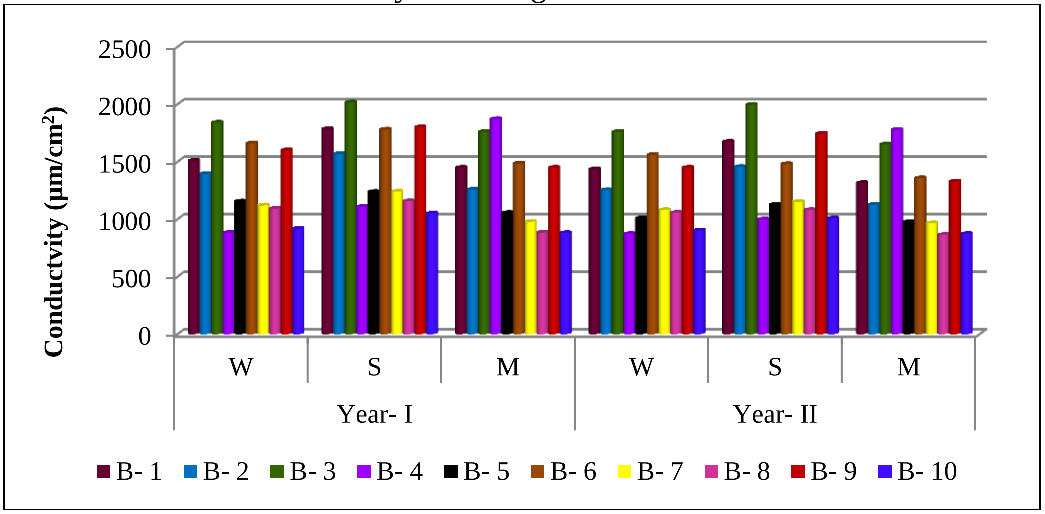

Figure- 7: Seasonal variation in Total Dissolved Solids at Badnagar block

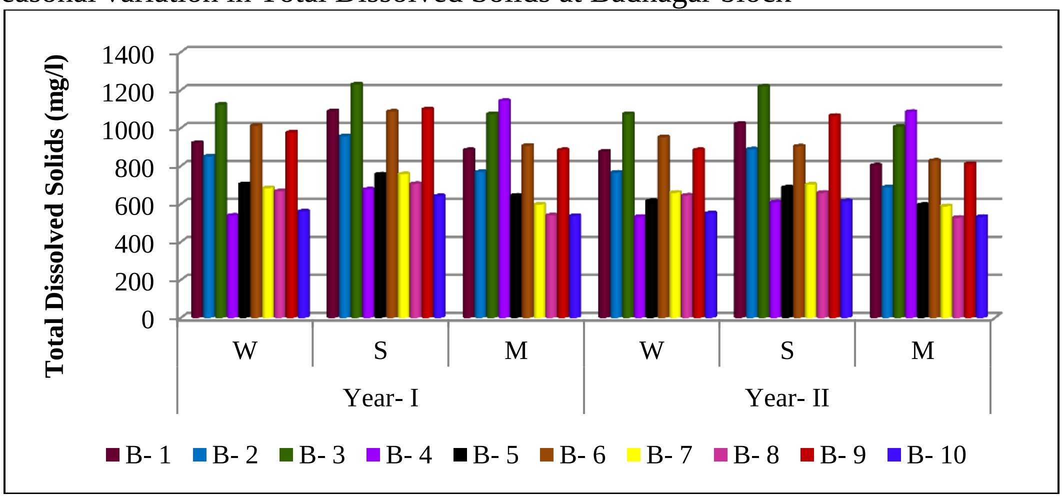

Figure- 8: Seasonal variation in chloride at Badnagar block

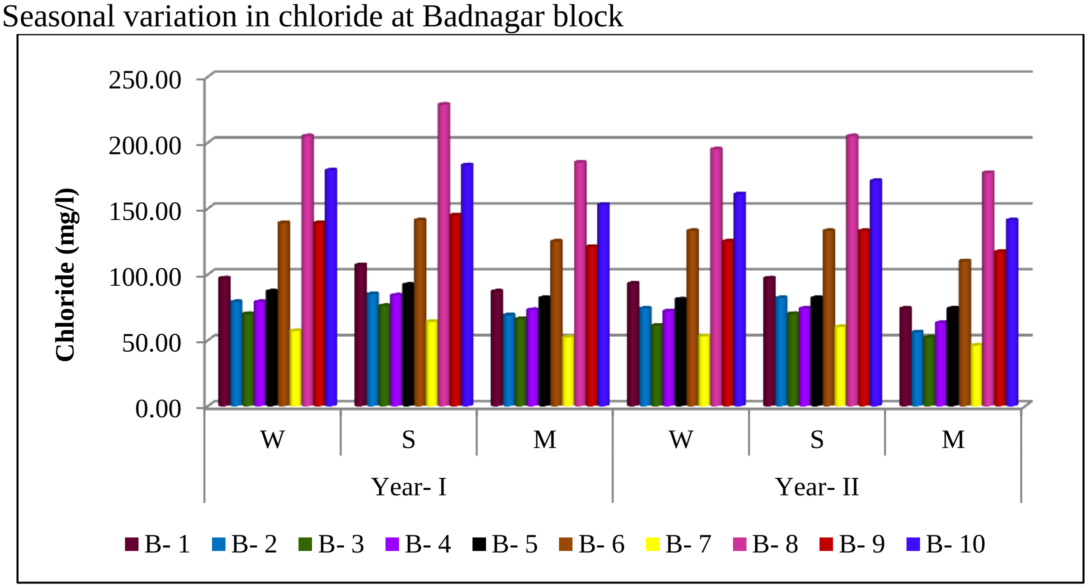

Figure- 9: Seasonal variation in fluoride at Badnagar block

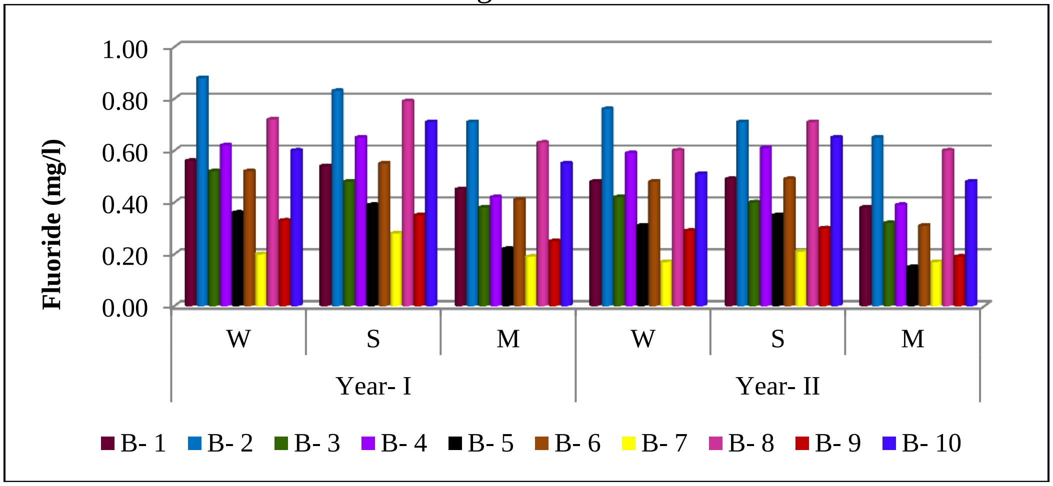

Figure- 10: Seasonal variation in Total alkalinity at Badnagar block

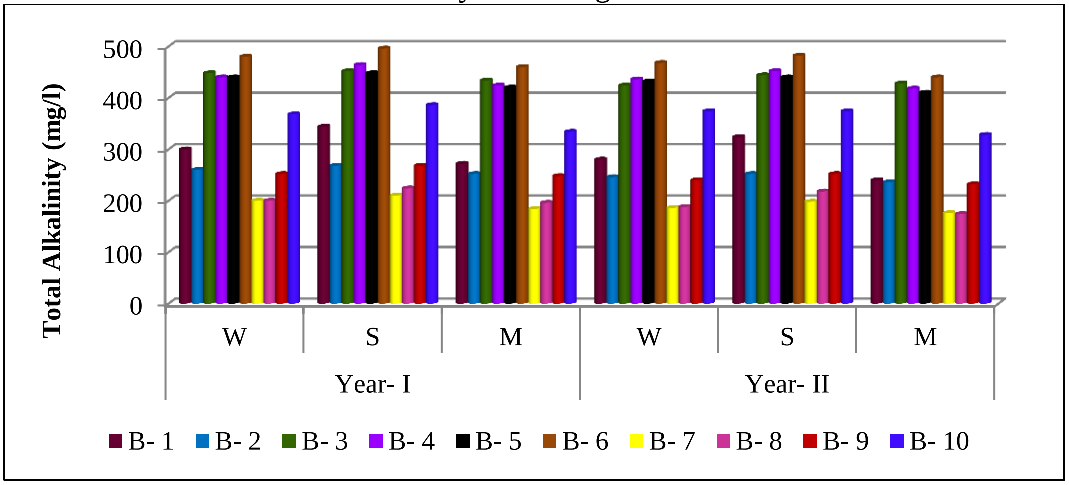

Figure- 11: Seasonal variation in Total hardness at Badnagar block

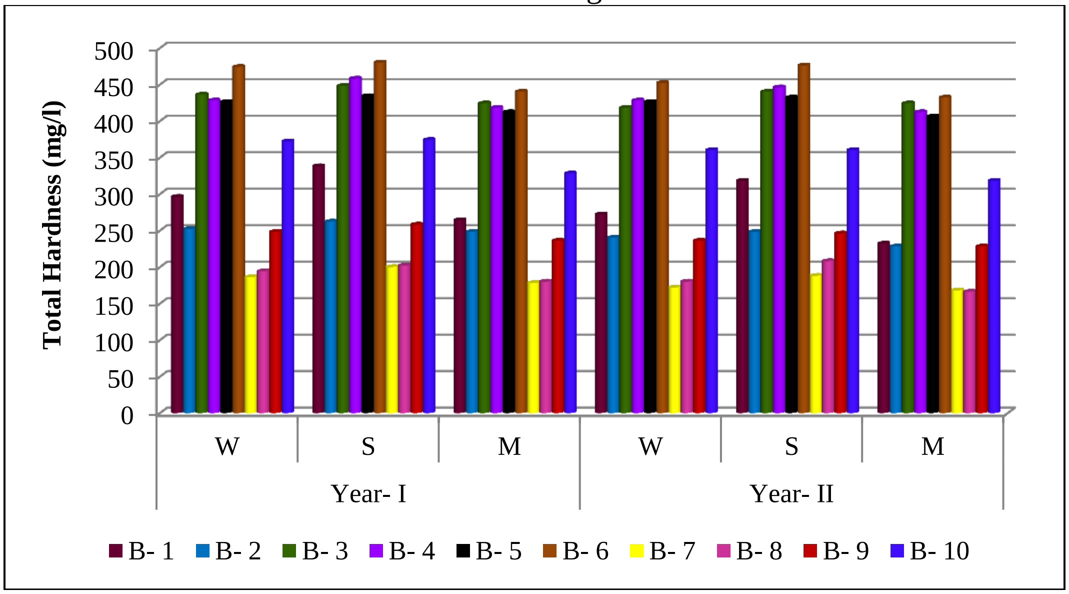

Figure- 12: Seasonal variation in Calcium hardness at Badnagar block

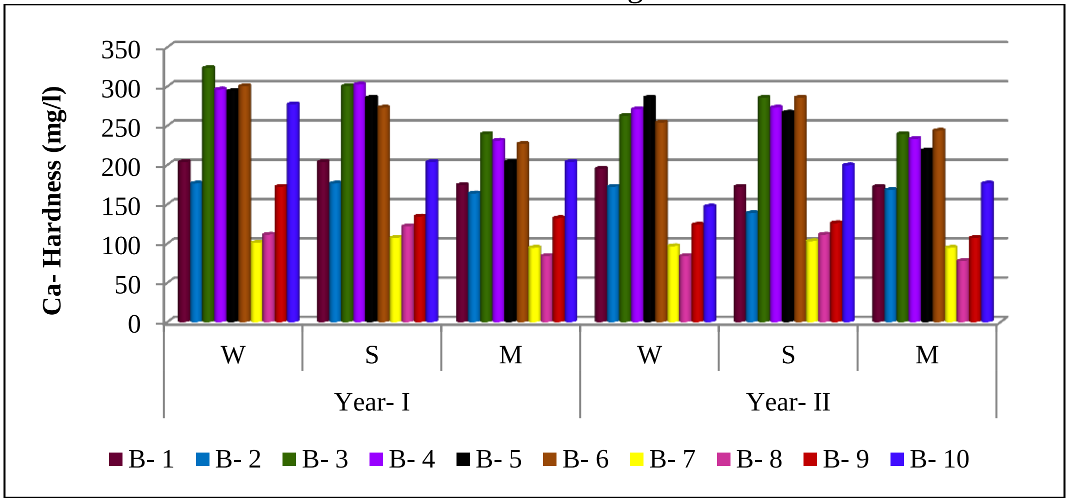

Figure- 13: Seasonal variation in Magnesium hardness at Badnagar block

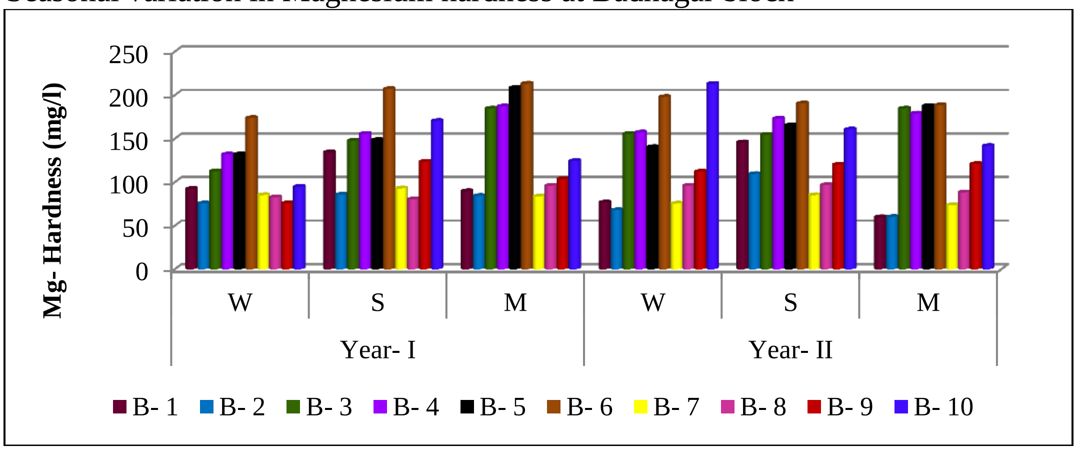

Figure- 14: Seasonal variation in nitrate at Badnagar block

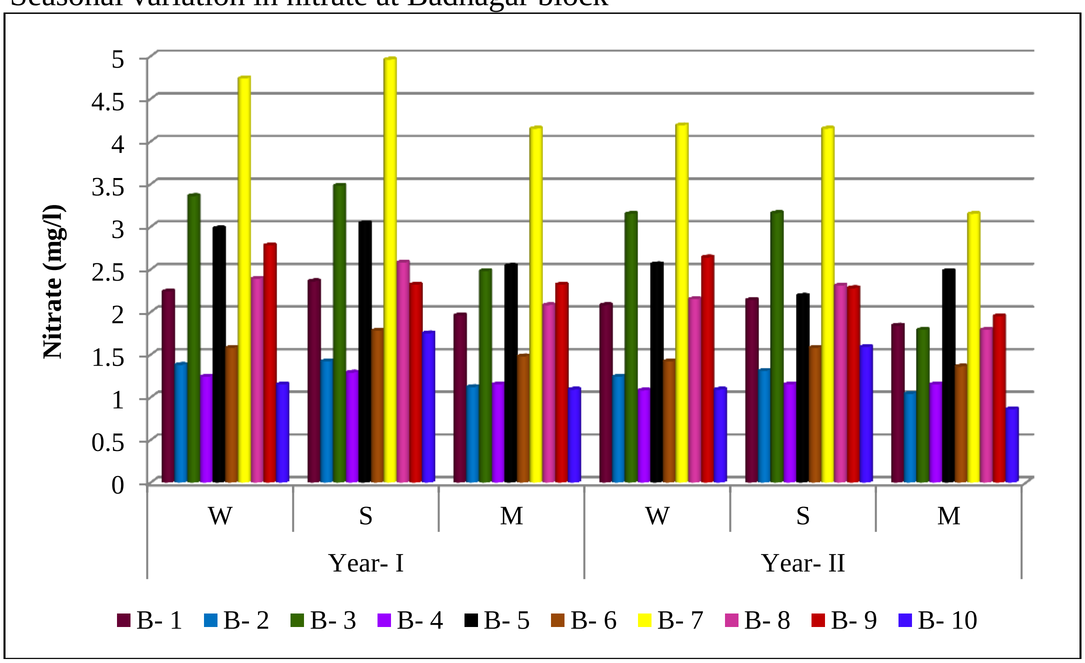

Figure- 15: Seasonal variation in Total coliform at Badnagar block

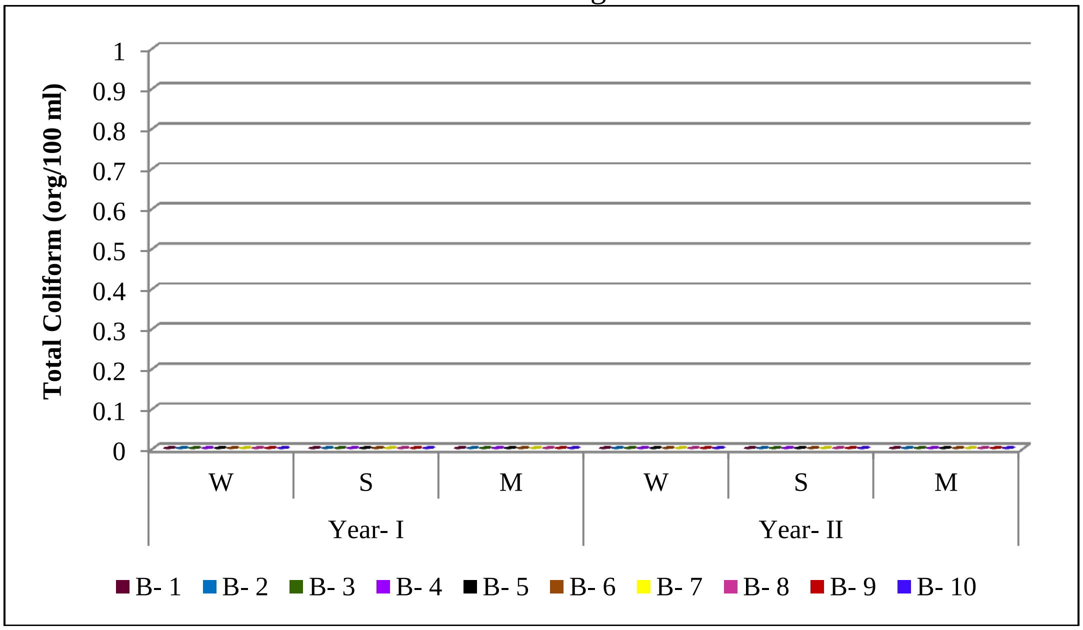

Figure- 16: Seasonal variation in Fecal coliform at Badnagar block