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# Ground Water Vulnerability Assessment of Bagh River Watershed (WGW-1/B) of India

Sandeep C. Hanuwate[1], Narendra M. Kanhe[2] and [3]Devendra Pandey

[1]Department of Civil Engineering, Manoharbhai Patel Institute of Engineering & Technology, Gondia, Maharashtra, India.

[2]School of Engineering, G.H. Raisoni University, Chhindwada, Madhya Pradesh, India.

[3]Department of Civil Engineering, Manoharbhai Patel Institute of Engineering & Technology, Gondia,

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**ABSTRACT**

Present paper ardently deals with the groundwater vulnerability assessment of Bagh River Watershed (WGW-1/B-designated by central ground water board) of Gondia District of Maharashtra State, India. The groundwater vulnerability assessment of the watershed is analyzed according to the guidelines provided by the APHE, ICMR, WHO and BIS10500. The parameters such as pH, EC, TDS, as well as Chloride, Nitrates, and Fluoride pre and post monsoon have been analyzed. Majority of the samples do not comply with EPA, ICMR, BIS and WHO norms for most of the water quality parameters measured. In order to protect groundwater Vulnerability of Bagh River Watershed of Gondia district, various parameters such as the industrial activities in the area, land cover/use data, hydro geological characteristics of upper aquifers, the lithology and nature of the soil zone for the area, and various predominant contaminating sources have been considered.



## Introduction

There are many different situations where water qualities are threatened by the existing industries in the watershed area which discharges hazardous and toxic wastes into the streams. There are about 20 Rice Mills, 1 Oil Extraction Plants, 1 Steel & Alloys units, 1 Paper & Pulps units, and about 70 Cottage manufacturing units in the BRW area. The wastewater disposed by these industries, which in turn contaminates surface and groundwater, contains hazardous elements such as zinc, copper, iron, and manganese in more than the maximum limits as prescribed by APHA, 2005. The groundwater contains dissolved solids; possesses physical characteristics such as odor, taste and temperature (Pandey & Rathore,2011). The natural quality of groundwater depends upon the physical environment, the origin, and the movement of water. As the water moves through the hydrological cycle, various chemical, physical and biological processes change its original quality through reactions with soil, rock and organic matter. Natural processes and human activities cause the changes in groundwater quality, directly or indirectly (Pandey, 2005). The type, extent and duration of induced changes of groundwater quality are controlled by the type of human influence; the geo-chemical, physical, and biological processes occurring in the ground, and the existing hydro geological conditions. These parameters are controlled by the volume and flux of water in the system which, in turn depend on climate, topography, and hydraulic conductivity (Pandey, 1999).

## Topography & Geology

The area is bounded by the longitudes 80º10’59”E and 80º22’05”E and latitudes 21º29’20”N and 21º38’16”N. The study area covers an area about 100.76 Sq.km as shown in the Figure 1. The Bagh River Basin is situated North-East of the District place. The total population of the study area is 31902 as per census 2011. The Bagh River & Pangoli River drains the area in the center to north of the district. The Study area falls under SOI Toposheet No. 64C/2, 64C/3, 64C/6 and IRS 1C, P101/RO57 LISS3. The maximum elevated point 317.79 MSL is situated in the north-west part of the BRW area and minimum elevation is 279.98 MSL is situated in the extreme north part of the BRW area. The BRW area is situated at the influence of The Bagh Rivers. The Pangoli River is the tributary of the Bagh River. The topography of the area is an undulating type with gentle slope and covers the Khardi and lateritic soils varying the thickness in the entire watershed area. The type of rocks is Granitic, Granite Gneiss & Quartzite of Archean age belongs to Amgaon and Sakoli Formation mainly occurs in BRW area.

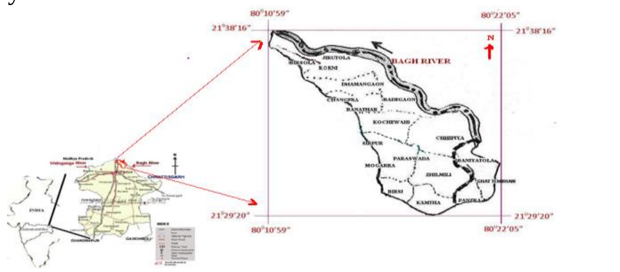


**Figure 1. Showing study area.**

Tele: +919890996427

E-mail address: devpand_2000@yahoo.com

The rocks are very hard and compact and possess practically no primary porosity. The Groundwater in the BRW area occurs at shallow depth and unconfined aquifers in zone. The average depth of wells varies from 9 to 20 m and diameters of Open well vary from 4 to 8 m where as Tube wells 0.15. The discharge varies from locality to locality.

**Climate & Drainage**

BRW experiences tremendous variations in temperature with very hot summers and very cold winters and it has an average relative humidity of 62 percent. Also records average rainfall more than 1200 mm each year in rainy season. During month of May daytime average temperatures will generally reach highs of around 42 °C. At night the average minimum temperature drops down to around 28 °C. In recent times the highest recorded temperature in May has been 48 °C with the lowest recorded temperature 20 °C. During the month of December end / January temperatures will generally reach highs of around 29 °C. At night the average minimum temperature drops down to around 13 °C. In recent times the highest recorded temperature in January has been 38 °C, with the lowest recorded temperature 0 °C. The Wainganga and the Bagh are the main perennial rivers, which drain along the district and roughly divide the area into two parts. The Bagh valley occupies the eastern part of the district. The Bagh river joins the Wainganga on its left bank as the later enters in the Gondia district. The Bagh River flows at an average velocity of 18 km/hour and has an overall length of about 166 Km out of which 26.391km.flow in the BRW area. The BRW valley floor is formed over granitic terrain. The elevation of the BRW ranges from 279 to 318 above MSL.

**Environmental Scenario and Land Use Pattern of the Area**

Nature is constantly changing state, with or without the intervention of man. But industrial activities can hasten these changes and cause them to go in unfavorable directions that result in environmental damages (Pandey, et.al. 2005). That is why priorities necessitate to be recognized. Whether or not, changes of natural state are tolerable depending on the priority in economic development strategy. Scarcity arises from the fact that environmental assets, such as clean water and air have a limited capacity to absorb material before they start changing their state (Pandey & Rathore, 2011). The alteration of state may be through demolition of water bodies due to extreme nutrients which support plant life in water. The most of the urban areas with large settlement have no sewerage network except Gondia town. There is no sewage treatment plant in the area and most of the wastewater and urban solid waste is discharged into the streams (Pandey, 2014). The medical wastes from various hospitals in the area also contaminate the surface water, as there is no treatment plant for solid waste. Some of the agricultural area in the districts is being irrigated by the industrial wastewater. Therefore, all of the above cited activities ultimately contaminate the groundwater. About 80% of the available groundwater is used for agricultural & industrial purposes, whereas 20% is used for potable water supply throughout the watershed area (Pandey & Jain, 2012). About 20% areas are under forest where as 75.00% of the total geographical area of BRW is cultivated area remaining 5% areas are used for human settlement and public utility. The supply for potable water throughout the watershed area is by ground water sources.

**Results and Discussion**

The hydro-geochemical analysis of groundwater in BRW are carried out as per standard procedure as prescribed by APHA, 2005. The hydro-geochemical analysis reveals that the groundwater in BRW is fresh to brackish and alkaline in nature, which is good for potable use and agricultural purpose. The average concentration of TDS is within the permissible limits for potable use in the entire BRW during the pre and post-monsoon as shown in Table 1.

**Table 1. Showing Pre Monsoon Physiochemical analysis of BRW.**

| S. No | Village Name | Census | pH | EC(μmho/cm) | TDS (mg/l) | $NO_3^-$ (mg/l) | F(mg/l) | Cl(mg/l) |
|---|---|---|---|---|---|---|---|---|
| 1 | Badegaon | 1246 | 7.42 | 1361 | 205.3 | 22.73 | 0.41 | 57.5 |
| 2 | Birsola | 2513 | 7.1 | 779.9 | 266.9 | 29.41 | 0.3829 | 130 |
| 3 | Bhadyatola | 689 | 7.18 | 1319 | 186.2 | 19.51 | 0.1364 | 74 |
| 4 | Jirutola | 577 | 7.48 | 745.5 | 738.2 | 10.502 | 0.5375 | 110 |
| 5 | Korni | 942 | 7.78 | 1048 | 612.8 | 6.76 | 0.368 | 225 |
| 6 | Dhamangaon | 1380 | 7.46 | 1253 | 781.3 | 34.92 | 0.134 | 75 |
| 7 | Satona | 2145 | 7 | 805.3 | 337 | 9.64 | 0.395 | 96 |
| 8 | Rajegaon | 1856 | 7.6 | 734.6 | 321 | 16.54 | 0.655 | 185 |
| 9 | Jagantola | 707 | 7.81 | 679 | 523.8 | 7.6758 | 0.466 | 142 |
| 10 | Kochewahi | 1305 | 7.79 | 757.1 | 683.3 | 5.006 | 0.406 | 154 |
| 11 | Shirpur | 1728 | 6.3 | 768 | 157 | 19.3 | 0.35 | 61 |
| 12 | Chiramantola | 719 | 7.16 | 1416 | 524.9 | 29.065 | 0.3 | 96 |
| 13 | Paraswada | 1010 | 7.32 | 1014 | 211.3 | 12.78 | 0.096 | 93 |
| 14 | Chhipiya | 2215 | 7.38 | 994 | 714 | 38.37 | 0.54 | 59 |
| 15 | Kamtha | 4346 | 7.16 | 932.4 | 641.4 | 33.752 | 0.706 | 245 |
| 16 | Zilmili | 1857 | 7.55 | 767.9 | 778.3 | 41.32 | 0.112 | 248.6 |
| 17 | Murpar | 1005 | 7.53 | 850 | 282 | 25.65 | 0.552 | 135 |
| 18 | Chargaon | 1762 | 7.02 | 1191 | 558.4 | 30.133 | 0.3134 | 107 |
| 19 | Rawanwadi | 2067 | 7.34 | 819.5 | 455 | 15.034 | 0.2213 | 140.5 |

In most cases the quality of groundwater in BRW is good and moderate in most of the open wells & hand pumps. TDS and Cl have been use as an indicator of groundwater salinity contamination in BRW areas Nitrate, EC and pH as an indicator of anthropogenic contamination and Fluoride used as an indicator of geogenic contamination of groundwater. High levels of Cl and TDS in the groundwater cause high salinity in the water supply. The quality of ground water depends on the different types of rock formations (Pandey & Rathore,2011). The types of rocks are Granitic, Granite gneiss & Quartzite of Archean age belongs to Sakoli Formation mainly occurs in BRW area. The rocks are very hard and compact and possess practically no primary porosity but highly fractured and jointed throughout.

Usually the pH of the water has a small variation due to buffering action of water with Carbon-di-oxide. About the BRW the pH value range lies within the permissible limit during pre-monsoon period but it is higher in Jirutola & Korni villages during post-monsoon period. The higher average pH observed in these villages is found to be above 8.2. This may be due of to Calcium Carbonate posture rock formations as shown in Figure 2.

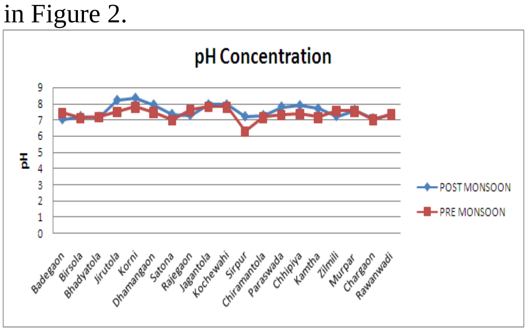


**Figure 2. Representation of Pre & Post Monsoon pH Concentration.**

Relatively High Electrical Conductivity in basin area indicating presence of high amount of dissolved inorganic substances in ionized form. Higher EC in the watershed area indicates the enrichment of salts in the groundwater. The value of electrical conductivity may be an approximate index of the total content of dissolved substance in water. It depends upon temperature, concentration and types of ions present (Hem, 1985).In the BRW area minimum value of EC is 169 µmho/cm and maximum value is 3050 µmho/cm are found as shown in Figure 3.

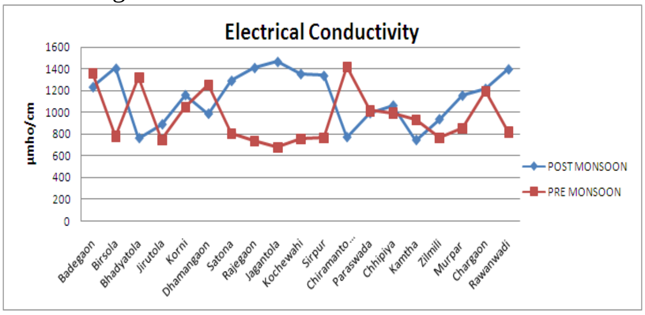


**Figure 3 Representation of Pre & Post Monsoon Electrical Conductivity.**

The Post-monsoon average TDS concentration is 937.6 mg/l in Jagantola village of the watershed area, which is within the permissible limit & Pre-monsoon average TDS concentration is found to be 778.3 mg/l in Zilmili village of the area. The main reason for the presence of dissolved solids may be due to geological formation or seepage from fertilizers or local contamination as shown in Figure 4. This may cause high salinity. For TDS, about 1.95% & 9.17% of drinking rural water wells and pumps exceed WHO standard in Pre-monsoon & Post-monsoon period. High concentration of TDS in the groundwater sample is due to leaching of salts from soil and also domestic sewage may percolate into the groundwater, which may lead to increase in TDS values.

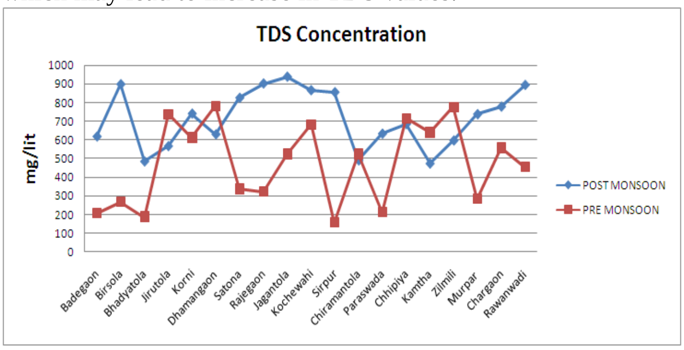


**Figure 4. Representation of Pre & Post Monsoon TDS Concentration.**

The average Chloride concentrations in all the wells of this watershed are found to be within the permissible limit during pre-monsoon period but alarming in few open wells and Hand pumps. During post-monsoon period the higher average concentration of chloride 272 mg/L is found in Murpar village and 265.2 mg/Lit Jagantola village which are above the WHO standard as shown in Figure 5. With increase in the salt concentration, plants find difficulties to extract water. Above permissible limits, chlorides are more toxic to some plants. The concentrations of Cl in 2.6% of rural water wells and pumps were higher than WHO standard in Post-monsoon period & in Pre-Monsoon period found to be 10.62%. Natural water contains low chloride concentration as shown in Table 1 & 2.

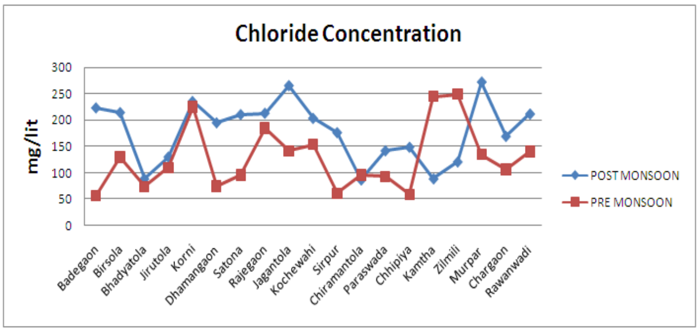


**Figure 5. Representation of Pre & Post Monsoon Chloride Concentration.**

**Table 2. Showing Post Monsoon Physiochemical analysis of BRW**

| S. No | Village Name | Census | pH | EC(µmho/cm) | TDS (mg/l) | $NO_3^-$ (mg/l) | F(mg/l) | Cl(mg/l) |
|---|---|---|---|---|---|---|---|---|
| 1 | Badegaon | 1246 | 7.03 | 1231.5 | 619.265 | 89 | 0.488 | 223 |
| 2 | Birsola | 2513 | 7.21 | 1402.7 | 897.71 | 105 | 0.2133 | 214.15 |
| 3 | Bhadyatola | 689 | 7.18 | 759.8 | 486.2 | 52.2 | 0.1568 | 88.4 |
| 4 | Jirutola | 577 | 8.2 | 887.5 | 568 | 54 | 0.5365 | 130 |
| 5 | Korni | 942 | 8.33 | 1158 | 741.3 | 64.7 | 0.655 | 235.3 |
| 6 | Dhamangaon | 1380 | 7.925 | 985.75 | 630.75 | 58 | 0.1798 | 194.75 |
| 7 | Satona | 2145 | 7.34 | 1289.3 | 825.29 | 81 | 0.1804 | 210.43 |
| 8 | Rajegaon | 1856 | 7.29 | 1408.9 | 901.6 | 114 | 0.2072 | 212.8 |
| 9 | Jagantola | 707 | 7.94 | 1465 | 937.6 | 84 | 1.7026 | 265.2 |
| 10 | Kochewahi | 1305 | 7.93 | 1352.4 | 865.57 | 108 | 0.2061 | 203.23 |
| 11 | Shirpur | 1728 | 7.21 | 1336.2 | 855.17 | 103 | 0.2437 | 176.17 |
| 12 | Chiramantola | 719 | 7.28 | 769.13 | 492.13 | 51 | 0.19 | 86.75 |
| 13 | Paraswada | 1010 | 7.8 | 990.7 | 634.25 | 66.75 | 0.2253 | 141.75 |
| 14 | Chhipiya | 2215 | 7.88 | 1061.1 | 684.8 | 76.9 | 0.1709 | 148.58 |
| 15 | Kamtha | 4346 | 7.68 | 742 | 474.8 | 57.8 | 0.2332 | 88.6 |
| 16 | Zilmili | 1857 | 7.23 | 934.6 | 598 | 63.4 | 0.172 | 120.7 |
| 17 | Murpar | 1005 | 7.6 | 1153 | 738 | 88 | 0.301 | 272 |
| 18 | Chargaon | 1762 | 7.08 | 1216 | 778.3 | 84.8 | 0.197 | 169 |
| 19 | Rawanwadi | 2067 | 7.33 | 1396.6 | 893.8 | 105.2 | 0.213 | 211.4 |

The average concentrations of Nitrate in some places are within the acceptable limit during pre-monsoon period but during post-monsoon it is found above the permissible limits in nearly all the villages of the BRW area. The higher average concentration of 41.32 mg/L Nitrate is found in Zilmili village during pre-monsoon period whereas during post-monsoon higher average concentration of 114 mg/L is found in Rajegaon village of the BRW area as shown in Figure 6. In the BRW area about 60% of rural wells and pumps Nitrate concentrations that exceed WHO guidelines in Post-monsoon period & about 46.85% in Pre-monsoon period. The level of Nitrate contamination has been rising so rapidly that most of areas drinking water wells and hand pumps are no longer suitable for human consumption. The increased concentration of Nitrate may be due to excessive application of nitrogen fertilizers or decay of plants and animals' residue or disposal of industrial wastewater or sewage. The toxicity of Nitrate leads to cardiovascular effects at higher dose level and Methomoglobinemia at lower dosage limits (Pandey & Rathore, 2011, Pandey, et.al. 2016).

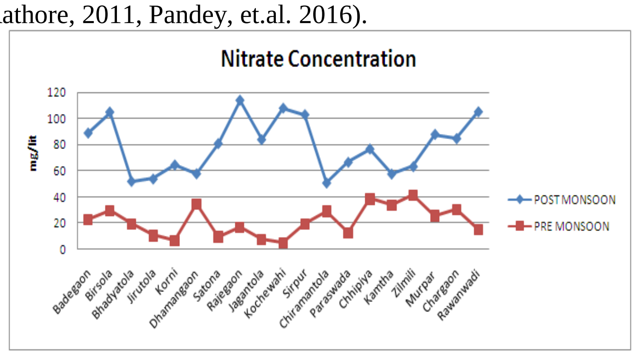


**Figure 6. Representation of Pre & Post Monsoon Nitrate Concentration.**

The average concentration of Fluoride is found to be within the permissible limit in most of the areas during pre-monsoon period. The higher average concentration of 1.7 mg/lit as shown in Figure 7. Fluoride is found in Jagantola during post-monsoon period which is more than the WHO standard. When the ingestion of Fluoride is above the permissible limit, it leads to skeletal and dental fluorosis. Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or runoff and infiltration of chemical fertilizers in agricultural areas. The significance of measuring fluoride lies in its health consequences. At low concentrations fluoride can reduce the risk of dental cavities. Exposure to somewhat higher amounts of fluoride can cause dental fluorosis (Pandey & Rathore, 2011). The Fluoride contamination is these pockets may be due to the presence of fluoride rich minerals like fluorite and appetite.

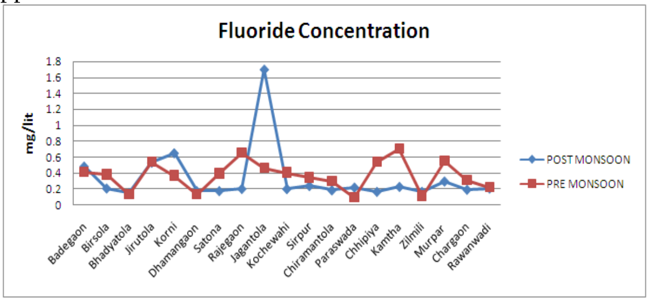


**Figure 7. Representation of Pre & Post Monsoon Fluoride Concentration.**

The groundwater of Jagantola and Murpar are identified as the most polluted in post-monsoon season whereas Zilimili in pre-monsoon season. State groundwater development authority may give priority to these places while implementing groundwater improvement measures. Based on the present study, Korani is identified as a potable source for the entire year. Bhadyatola, Jirutola, Dhamangaon, Chiramantola, Kamtha and Chhipiya are identified as less contaminated areas from this study. Hence the developmental activities in terms of agriculture or water resources development can be carried out in these villages. Since, major industries are not present in the BRW or other pollution sources, the natural geochemistry, anthropogenic activities and paddy crop pattern of the watershed is the reason for the higher level of Nitrate which increases with time.

## Conclusion

The groundwater contamination in the BRW is mainly due to the leaching of nitrate present on the surface with percolating water. In the BRW the contamination is also due to the percolation of large amount of organic wastes from effluent nitrate fertilizers widely used in paddy forming in the BRW and other wastes like sewage disposal which on decomposition by microorganism results in the production of nitrates. Potable water that gets contaminated with nitrates can prove fatal especially to infants who are fed with nitrate contaminated water as it restricts the amount of oxygen that reaches the brain causing the 'blue baby' syndrome and also linked to cause digestive tract cancers as reported earlier. It is also reported to cause algae to bloom resulting in eutrophication in surface water. Higher Electrical Conductivity in BRW indicates presence of high amount of dissolved inorganic substances with enrichment of salts in the groundwater.

## References

[1] American Public Health Association "American Water works Association and Water Pollution Control Federation. Standard methods for the examination of water and wastewater", American Public Health Association, Washington, D.C, 1989.

[2] American Public Health Association "Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association, and Water Pollution Control Federation", 19th edition, Washington, D.C, (1995).

[3] APHA – AWWA and WPCF "Standard Methods for the Examination of Water and Wastewater", 16thEd. Washington D.C, APHA, 1268, (1984).

[4] APHA. Standard Methods for Examination of Water and Wastewater, 16th American Public Health Association, Washington, DC. (1985).

[5] Gazetteer of India, Maharashtra State Bhandara District (Revised Edition), 23- 30, (1979).

[6] Hem, J.D. "Study and interpretation of the chemical characteristics of natural water", USGS Water-Supply Paper 2254, 3rd Ed., 2254, 117–120, (1985).

[7] Pandey Devendra, "Groundwater Vulnerability Maps of Bhandara District, (M.S.), India", Proc. International Conference on Water Asia'99, 230-238, New Delhi, (1999) .

[8] Pandey, Devendra, Jain, Pramod, "Selection of Prospective Waste Disposal Sites for Gondia Municipal Council of Maharashtra, India", Int. J. Earth Sc. & Eng., ISSN 0974-5904, Volume 05, No. 04, 825-830,(2012).

[9] Pandey Devendra, Rathore S.S., Nashine A.L. & Asati ,S.R., "Environmental Protection Map of Bhandara & Gondia Districts, (M.S.) , India", Proc. 2nd International Congress of Chemistry and Environment, Journal of Chemistry & Environment, 554-558, (2005).

[10] Pandey, Devendra, Rathore S.S., "Water Quality Assessment of Gondia & Bhandara Districts of Maharashtra, India, Int. J. Res. Chem. Environ.", Vol. 1 Issue 1, 114-118,(2011).

[11] Pandey Devendra, Katpatal, Y.B.,Kundal, P.P. "Natural Disasters Vulnerability Assessment Of Gondia District, Maharashtra, India Using DTM & GIS Techniques", International Journal of Research in Engineering and Technology, Vol. 3 Issue 9, 165-169, (2014).

[12]Pandey Devendra, Katpatal, Y.B.,Kundal, P.P., Chandrayan, V.R, Nitrate Contamination Indexing of Subsurface Water of Upper Wainganga Drainage Basin of India, International Journal of Inovative Research in Science, Engineering & Technology,ISSN: 2319-8753/ISSN: 2347-6710, Vol.05, Issue 1,161=170, (2016).