

# **Nitrate Contamination Indexing of Subsurface Water of Upper Wainganga Drainage Basin of India**

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**ABSTRACT:** The present paper fervently deals with the ground water quality assessment of upper Wainganga drainage basin in Gondia district, Maharashtra, India. The prime objective of work is to determine the causes for higher nitrate concentration in groundwater and its impact on human health. A total 40 samples were collected from open and bore wells. The ground water quality analysis based on Nitrate concentration was carried out. The nitrate concentration was analysed with UV spectrometer using appropriate standards. The highest concentration recorded was 120 mg/L and the lowest concentration was 30 mg/L that exceeds the maximum permissible limit of 20 mg/L for potable water set by Indian Council of Medical Research. The presence of high nitrate concentration in the area is attributed to the factors like groundwater present at shallow unconfined aquifer, bedrock dissolution in the course of groundwater migration, presence of granitic gneiss formation, poor sanitation facilities, leaching from indiscriminate dumping of animal waste, lack of drainage system and excessive use of fertilizers.

**KEYWORDS:** Upper Wainganga Drainage Basin (UWDB), Bureau of Indian Standards (BIS), Indian Council of Medical Research (ICMR), Ground Water Quality Assessment (GWQA).

## **I. INTRODUCTION**

Earth is also called as 'blue planet' since 70 % vicinity of it has been roofed by water store. The total water quantity on the earth is about 1.35 billion cubic kilometres (Frank 2009). About 97.1 % has been locked into oceans as saline water. Ice sheets and glaciers have under arrest of 2.1 %. Only 0.2 % is the clean water present on the earth, which can be used by human being for diversified purposes. The left over 0.6 % is in underground form. But regrettably it is getting polluted day by day due to dissimilar anthropogenic and geogenic factors. So it is urgently required to conserve the water and prevent it from every kind of pollution. There should be correct water analysis and monitoring on regular basis. Use of water has grown-up spirally with population enlargement and agro industrial expansion during last three decades. More than 85% of the rural water supply schemes in the country are based on ground water recourses. Rural India has more than 700 million people residing in about 1.42 million habitations spread over 15 diverse ecological regions. Meeting the drinking water needs of such a large population can be a daunting task. Around 37.7 million Indians are affected by waterborne diseases annually, 1.5 million children are estimated to die of diarrhoea alone and 73 million working days are lost due to waterborne disease each year. The resulting economic burden is estimated at \$600 million a year ([www.naandi.org](http://www.naandi.org)). While 'traditional diseases' such as diarrhoea continue to take a heavy toll, 66 million Indians are at risk due to excess fluoride and nitrate and 10 million due to excess arsenic content in groundwater ([www.fluoridealert.org](http://www.fluoridealert.org)). In all, 195813 habitations in the country are affected by poor water quality ([www.ddws.nic.in](http://www.ddws.nic.in)). Similarly, out of total irrigated area in the Maharashtra state, more than 50% area of rabbi crops is

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irrigated by groundwater (Pandey, et al., 1998, Pandey, 1999). Thus groundwater plays a very significant function in the state's economy and therefore needs to be regularly monitored scientifically both in terms of quality and quantity, for sustainable development and management. In order to manage water as prime natural resource, in reference to basic human need and a precious national asset. It is therefore mandatory, to maintain its wholesomeness by way of planning, development & pollution control. Government of India passed National Water Policy under the auspices of Ministry of Water Resources in April 2002. In pursuance of a directive contained in the National Water Policy 2002 and recommendations of the Maharashtra Water and Irrigation Commission, the Government of Maharashtra announced the Maharashtra State Water Policy in July 2003. This path breaking policy was proposed to determine the manner in which the planning, development and management of water resources were to be carried out during the following period of 20 years. Although state water policy provides a platform for regular monitoring of surface and ground water quality but water pollution has not yet been adequately addressed in any policy document in India. A public wakefulness and education agenda forms a vital part of the groundwater protection plan.

A groundwater shield policy should include a dual approach: legislation and enforcement for pollution control for minimizing nitrogenous inputs to the environment which can be complimented by public enlistment and illumination program. Ground water is now recognized to be a fundamental component in the comprehensive joint management of land, water and waste throughout the nation (Dan-Hassan, et. al., 2013). The occurrence of nitrate in groundwater is a serious problem. Since nitrate is a stable and highly soluble ion with low potential for co precipitation or adsorption (Allhoff & Lin, 2008). The harmful effects of nitrate in drinking water sources towards health and socio- economic aspects are a serious concern for well being of urban and rural communities. It is therefore essential to build up groundwater nitrate management approach, particularly for understanding the pollution processes and the role of the unsaturated zone in groundwater protection (Sunitha, 2013). At the megacities, high levels of sewage sludge have caused serious groundwater pollution. The above confirms that the main source of nitrate in groundwater is anthropogenic pollution but such nitrate inputs are manageable. In the rural setting voluntary action regarding nitrate management is essential, but overall legislation and control are also needed (Maheshwari, et.al. 2012).

There are many different situations where surface and subsurface water quality is threatened by the existing industries in the Gondia district. There are many Rice Mills, Oil Extraction Plants, Steel & Alloys units, and Cottage manufacturing units in the Gondia district. The wastewater disposed by these industries contains hazardous elements and contaminates surface water and later on contaminates groundwater (Pandey, 1999, Pandey, 2013). The type, extent, and duration of induced changes of water quality are controlled by the type of human influence; the geo-chemical, physical, and biological processes occurring in the ground; and the existing hydrogeological conditions. These parameters are controlled by the volume and flux of water in the system which, in turn, depends on climate, topography, and hydraulic conductivity (Pandey, et al., 2005, Pandey & Rathore, 2011).

The deadlier diseases like chronic inflammatory, blue-baby cancer, edema of eyelids, tumour, congestion of nasal mucous membranes and pharynx, stuffiness of the head and gastrointestinal, muscular, reproductive, neurological and genetic malfunctions caused by nitrate have been documented (Abbasi et al.1999, Aggarwal & Shishodia, 2006, Banerjee, et al., 2006 Bharadwaj, 2005, Elst & Tjalma 2007, Johnson, 1998- Piazza et al., 2009, Tsuji & Karagatzides 2001, Umanzor & Pineda2001). Therefore, monitoring Nitrate is important for safety assessment of the environment and human health in particular. With reference to this backdrop, present study is aimed at assessment of ground water quality in the Gondia district stretch of the upper Wainganga drainage basin, considering the spatial and sequential variations in nitrate content and also to evaluate the condition of the ground water quality for potable purposes as per the Union Health Ministry, Government of India and followed by ICMR, BIS and WHO guidelines.

## II. STUDY AREA

The area is bounded by the longitudes 79°48'12.31"E and 80°13'01.98"E and latitudes 21°16'00.85"N and 21°37'58.48"N. The upper Wainganga drainage basin covers an area about 848.34 Sq.km in the Gondia district. The UWDB is situated north-west of the district and covers 206 villages. The total population of the villages' falls under UWDB is 130400 as per census 2011 as shown in Figure1.

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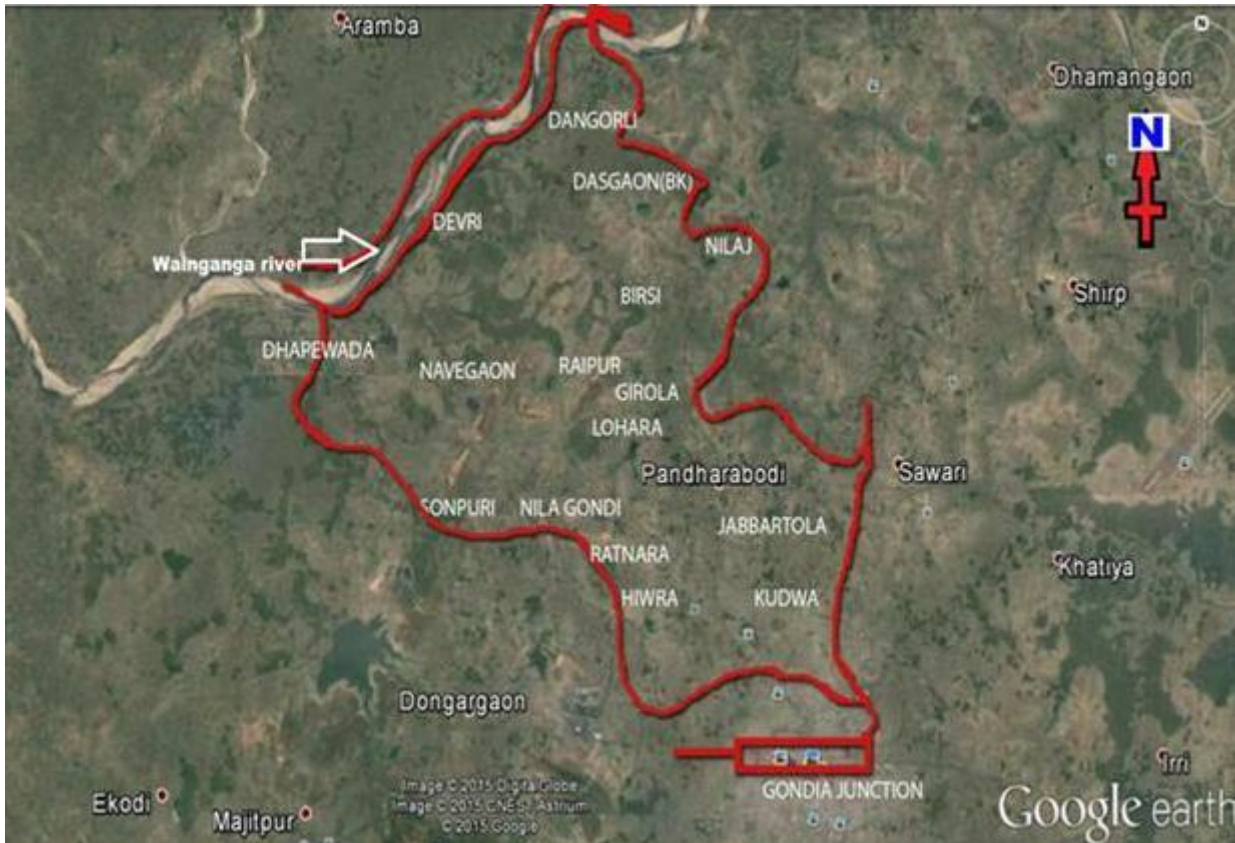


Figure1 showing the location map of the UWDB n (Curtsey: Googleearth.com).

The Wainganga River drains the area in the north-west from north to west. The maximum elevated point 610 Mts. level is situated in the centre part of the UWDB and minimum elevation is 267 Mts. level. The satellite image of Study area is shown in Figure 1.

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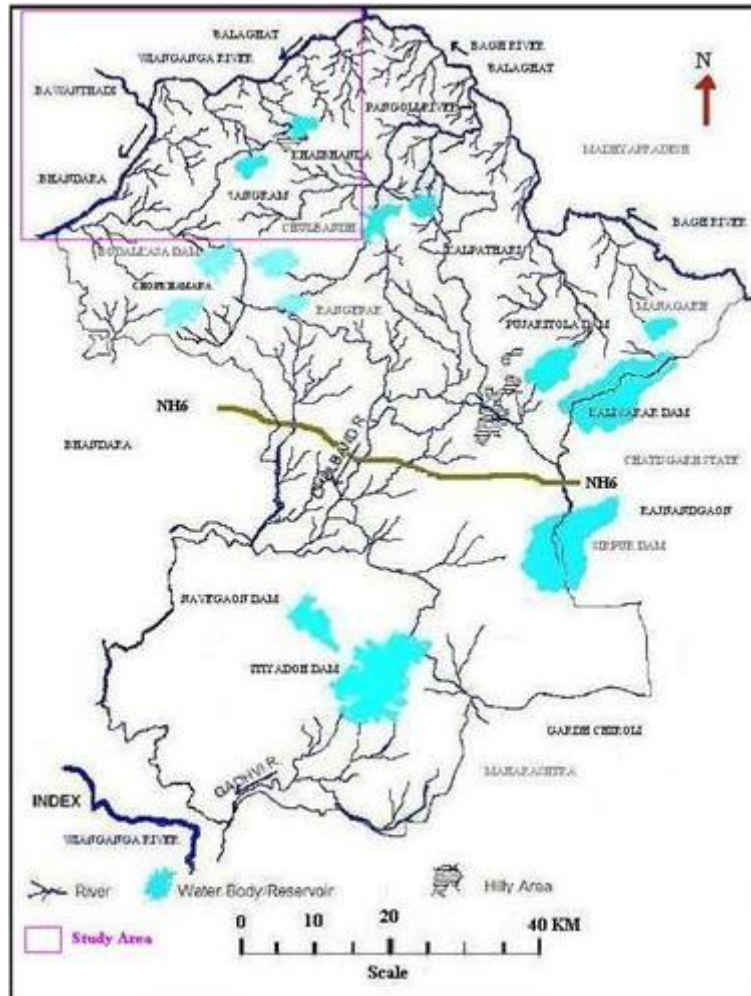


Figure 2 showing drainage system of UWDB of Gondia district.

The Bodalkasa River is the tributary of The Wainganga River. The topography of the area is an undulating type and covers the Kardhi (similar to black cotton) and lateritic soils throughout the area. As a result the land is very fertile and the main occupation of inhabitants is paddy agriculture. The UWDB drainage system of study area is as shown in Figure 2.

### III. MATERIALS AND METHOD

#### Collection of Water Sample

The present study was conducted in the UWDB of Gondia district, in the month of February- March. The total 40 water samples were collected from 18 villages. The samples were collected in sterilized bottles. The water samples were basically underground water which is used for drinking purpose mostly from the sources like schools, public health centre and community wells or bore wells. Concurrently, the diameter and depth of the open and bore wells were also recorded during sample collection. Then these samples were tested in the laboratory on the same day. Determination of nitrate concentration is a difficult task because of the relatively complex procedures required, on account of high probability of interfering constituents. In the present study the UV Spectrophotometric screening method has been adopted to determine the nitrate concentration in water samples.



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## Ultraviolet Spectrophotometric Screening Method

The UV Absorption Spectroscopy method is probably the simplest, so long as sample does not contain appreciable concentrations of organic matter and nitrate > 10 mg/L. This technique is useful for screening samples that have low organic matter contents, which are uncontaminated natural waters and potable water. The nitrate calibration curve follows Beer's law up to 11 mg N/L (Amstrong, 1963). Measurement of UV absorption at 220 nm enables rapid determination of nitrate. Because dissolved organic matter also may absorb at 220 nm and nitrate does not absorb at 275 nm, a second measurement made at 275 nm may be used to correct the nitrate value. The extent of the empirical correction is related to the nature and concentration of organic matter and may vary from one well to another well. Consequently, this method is not recommended if a significant correction for organic matter absorbance is required, although it may be useful in monitoring nitrate levels within a water body with a constant type of organic matter. Correction factors for organic matter absorbance can be established by the method of additions in combination with analysis of the original nitrate content by another method.

## IV. RESULTS & DISCUSSION

Potable water polluted with chemicals causes problem to health and leads to water-borne diseases, which can be prohibited by taking measures even at the household stage. The increased demand linked supply causes the water storage to turn down and surface water quality to decline. The results of analysis of hydrochemical data from 40 subsurface water samples from selected locations in the area have been evaluated as indicated in the Table1. The water samples were collected from the open and bore wells. The level of nitrate does reflect the accurate water quality for potable usages and hence has been used in this paper as a pointer of ground water pollution in UWDB. The average nitrate concentration is found to be 82 mg/l in the area which is hazardously higher than BIS, WHO & ICMR standards. The samples from almost every village had the traces of nitrate present in the ground water above the permissible limit. The comparative study for all concerned villages is shown in figure 3. The highest average concentration is found out in Sonpuri is 105.5 mg/L while the lowest is found in Raipur 36 mg/L. There are 8 villages namely Kudwa, Sonpuri, Pandhrabodi, Dasgaon (bk), Dangorli, Lohara, Deori and Jabbartola having nitrate level of about 100mg/L which far beyond maximum permissible limit by any standard. There no alternative domestic water supply system is available in the area hence inhabitants are required to rely only on ground water sources to meet their daily needs. Only two villages namely Raipur & Hiwara are found to have the level of nitrate respectively as 36mg/L and 41.67mg/L within desirable limit of BIS and WHO. Yet portable water of this area is not safe according to ICMR. All in all almost 100% areas under study is nitrate affected as per ICMR limits. About 88% area is nitrate affected as per WHO and BIS limit as shown in the Figure 3.

Sr. No	NAME OF VILLAGE	CENSUS	LOCATION	TPYES OF WELL	NO <sub>3</sub> mg/l
1.	Kudwa	11549	M.I.E.T Collage	OPEN WELL	<b>90</b>
2.	Kudwa	11549	Pharmacy Collage	OPEN WELL	<b>102</b>
3.	Kudwa	11549	Government School	HAND PUMP	<b>111</b>
4.	Hiwara	1507	Government Primary School	HAND PUMP	<b>40</b>
5.	Hiwara	1507	Agricultural Collage	HAND PUMP	<b>39</b>
6.	Hiwara	1507	Beside Dinesh Kirana Store	HAND PUMP	<b>46</b>
7.	Ratnara	3930	Middle School	HAND PUMP	<b>95</b>

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8.	Ratnara	3930	Public Health Center	OPEN WELL	<b>49</b>
9.	Ratnara	3930	Junior College	OPEN WELL	<b>66</b>
10.	Salaitola	636	Public Open Well	OPEN WELL	<b>67</b>
11.	Salaitola	636	Primary School	HAND PUMP	<b>72</b>
12.	Deori	1490	Residence of Devlal Baghele	OPEN WELL	<b>108</b>
13.	Deori	1490	Government School	OPEN WELL	<b>90</b>
14.	Dhapewada	2788	Beside Mukul Wasnic House	HAND PUMP	<b>110</b>
15.	Dhapewada	2788	Public Health Center	HAND PUMP	<b>98</b>
16.	Dhapewada	2788	Government High School	HAND PUMP	<b>50</b>
17.	Navegaon	2541	Community Well	OPEN WELL	<b>80</b>
18.	Navegaon	2541	Tribal Residential School	OPEN WELL	<b>107</b>
19.	Sonpuri	834	Community Well	OPEN WELL	<b>103</b>
20.	Sonpuri	834	Residence of R. Meshram	OPEN WELL	<b>108</b>
21.	Girola	1710	Residence of S. Ambule	HAND PUMP	<b>45</b>
22.	Girola	1710	Government School	HAND PUMP	<b>62</b>
23.	Pandhrabodi	4458	Tribal Residential School	OPEN WELL	<b>110</b>
24.	Pandhrabodi	4458	Dahade Brother's Cloth Center	HAND PUMP	<b>100</b>
25.	Dangorli	2931	Community Well	OPEN WELL	<b>100</b>
26.	Dangorli	2931	Government School	HAND PUMP	<b>95</b>
27.	Dasgaon (Bk.)	2212	G.E.S.High School And Jr. Collage	HAND PUMP	<b>90</b>
28.	Dasgaon (Bk.)	2212	Public Health Center	HAND PUMP	<b>100</b>
29.	Dasgaon (Bk.)	2212	Community Well	OPEN WELL	<b>120</b>
30.	Lohara	1570	Marathi Middle School	HAND PUMP	<b>110</b>
31.	Lohara	1570	Residence of Chotu Lihlare	OPEN WELL	<b>85</b>
32.	Lohara	1570	Community Well	OPEN WELL	<b>120</b>

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33.	Raipur	1539	Residence of Simrat Kohare	HAND PUMP	42
34.	Raipur	1539	Government Hindi Middle School	HAND PUMP	30
35.	Birsi	2287	Hindi Primary School	HAND PUMP	70
36.	Birsi	2287	Tudjabai Bhalavi's Residence	OPEN WELL	55
37.	Jabbartola	931	Rani Awantibai Square	HAND PUMP	108
38.	Jabbartola	931	Primary School	HAND PUMP	100
39.	Gonditola	660	Residence of Om Rai	OPEN WELL	45
40.	Gonditola	660	Community Well	OPEN WELL	62

Table 1 showing status of Nitrate level for various villages of UWDB.

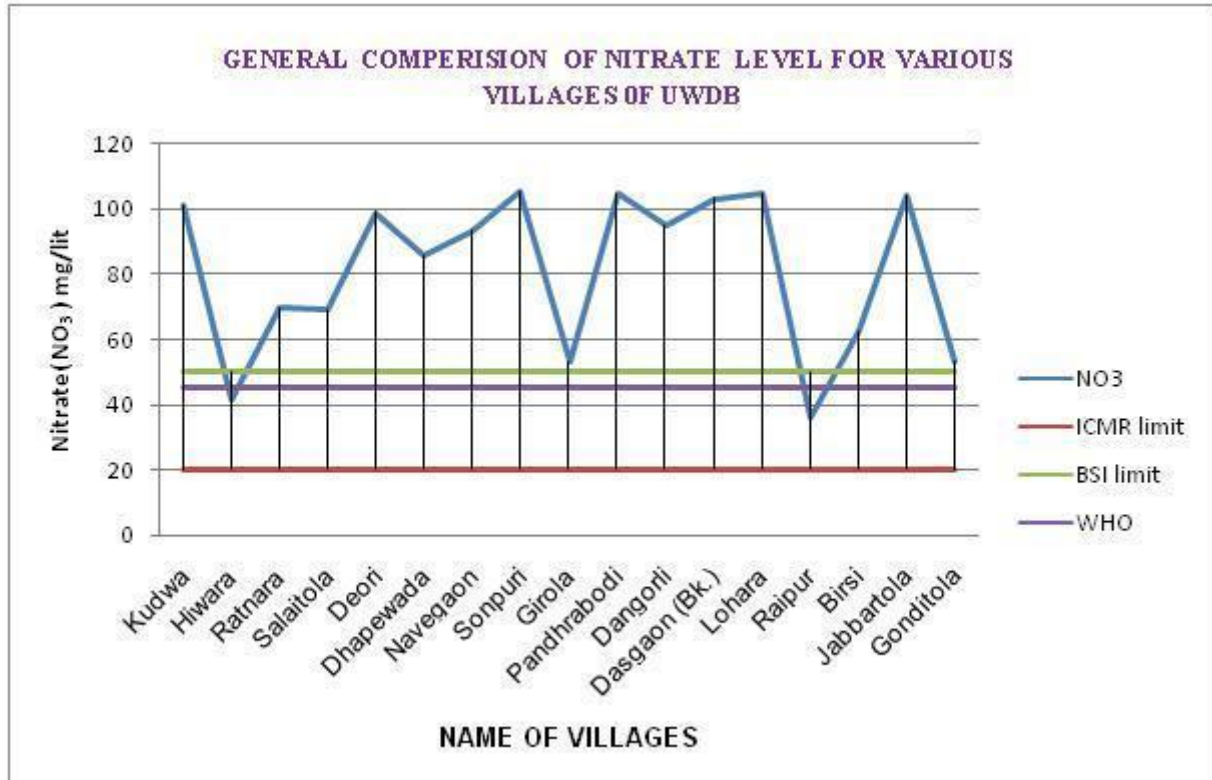


Figure 3 showing Comparison of Nitrate level for various villages of UWDB.

### Trend of Flow of Nitrate in UWDB

Since nitrate being stable and highly soluble in water it flows with water and its concentration varies with time. It flows from higher to lower concentration level. The area which is away from river Wainganga is having higher concentration.

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But in course of time this nitrate will runoff towards Wainganga River on account of concentration gradient and there is a possibility that the concentration in the area near Wainganga River will reach above 100mg/L in due course of time as shown in Figure 4. Even though the water of village Raipur seems to be at lower concentration but during the course of time this water may also get higher level of nitrate due to its retention on account of overall higher concentration of surrounding regions.

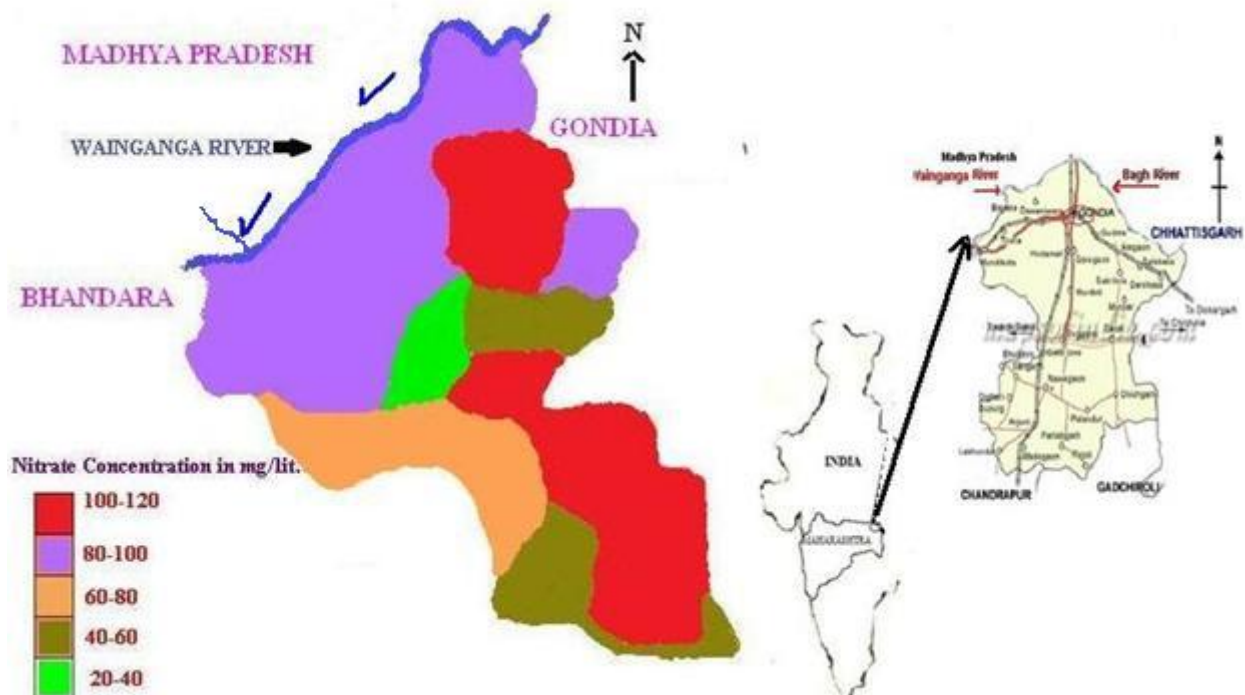


Figure 4 showing variable concentration level of Nitrate in UWDB.

### Hazardous Impacts of Nitrate on Human Health

Nitrogen is an essential input for the sustainability of agriculture. However, nitrate contamination of groundwater is a worldwide problem (Self and Waskom, 2014). Nitrogen is essential for vegetation and organisms, as it is an essential component of protein. Nitrogen exists in the environment in many forms and changes forms as it moves through the nitrogen cycle. Potable water that gets contaminated with nitrates can prove fatal especially to infants that drink formula milk as it restricts the amount of oxygen that reaches the brain causing the 'blue baby' syndrome. It is also linked to digestive tract cancers. It causes algae to bloom resulting in eutrophication in surface water (Candelaria et al., 2006, Elst & Tjalma 2007, Pandey, 2013). The occurrence of high nitrate levels in groundwater has to be recognized as a threat to humans and animals. Infant methemoglobinemia and nitrate poisoning of livestock occur at unexpected times and place (Avery, 1999, Johnson, et al., 1987). An important reason is that nitrate concentrations are variable, particularly under extreme climatic conditions (Schuddeboom, 1995, Lowrance, 1992).

The groundwater contamination is due to the leaching of nitrate present on the surface with percolating water. Johnson and Reynolds (1977) found similar nitrate concentrations in stream water from plutonic rock such as, Granite and from metamorphic rock such as Schist, Quartzite and Slate. The Nitrate contamination is common in basic extrusive igneous formation and also may be attributed to the percolation of large amount of organic wastes from effluent nitrate fertilizers and other wastes like sewage disposal which on decomposition by microorganism results in the production of nitrates. The study done by Johnson and Reynolds (1977) and Sangole, (2012) found similar nitrate concentrations from granitic aquifers in range between to be 26 and 190 mg/L which agreed well with the data collected in the present study for area having granitic gneisses formation.



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Concentration of nitrate has been largely increased as a result of anthropogenic and geogenic activities. They can disturb vital biochemical processes, which pose a threat for the health of human beings and aquatic life (Maheshwari, 2010, Tredoux, et.al. 2009, Maheshwari, et.al. 2012). Plants and animals absorb these elements from soils, sediments, and water by contact with their external surfaces, through ingestion and also from inhalation of airborne particles and vaporized metals (Madaan & Mudgal, 2009, Mudgal et.al 2010, Mudgal et.al 2010).

Wastewater in the upper soil layer either from the cesspools or the disposal ponds could infiltrate to the groundwater aquifer. The absence of a sewage system encourages such types of contamination by nitrate. In study area it can be seen that there is no proper drainage facility. Due to which Livestock waste and other waste from village gets percolated into underlying shallow depth unconfined aquifer. Most of the samples collected from the areas like school, community wells and public health centres. It is observed that many of the wells and hand pumps are not properly located. Many of the wells are near Septic system, livestock shed, waste disposal site. There are some of the wells poorly constructed; some of them are at lower heights flush to ground level because of that, the runoff from surface get enter into wells. In over study we found out that most of the wells are at shallow depth of ground water unconfined aquifer. Nitrate contamination generally decreases with increasing depth of ground water table. The water at shallow depth is closer to land surface and potential source of ground water contamination. In contrast contamination is less likely to occur in deeper ground water unconfined aquifer because contaminants have further to travel. The increased uses of nitrate fertilizers in the villages enhance the contamination of groundwater. The local farmers of the study area admitted the use of excessive nitrate fertilizers and believe that it is necessary to have better agricultural productivity.

## V. CONCLUSION

The nitrate concentration in groundwater can vary over a wide range depending on the aquifer and its recharge characteristics. The groundwater contamination is due to the leaching of nitrate present on the surface with percolating water. The Nitrate contamination is common in basic extrusive granite formation which has extensive occurrence in the UWDB and also is attributed to the percolation of large amount of organic wastes from effluent nitrate fertilizers widely used in paddy forming in the UWDB and other wastes like sewage disposal which on decomposition by microorganism results in the production of nitrates. The local farmers of the study area admitted their inclination to use excessive nitrate fertilizers for better agricultural productivity. A judicious crop specific use of nitrate fertilizer coupled with effective management of household manures and continuous monitoring may reduce contamination to a desirable level in ground water in the UWDB for well being health of inhabitants.

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