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Impact of Nitrogenous Fertilizers on the Quality of Shallow Groundwater in the Upper Alluvial Plains of Narmada Valley Between Hoshandabad and Bhilaria, M.P., India

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Abstract : The present study has been undertaken to motivate the farmers to use the high nitrate water for irrigation as a substitute of nitrogenous fertilizers available in over a stretch of about 45 kms from Hoshangabad to Bhilaria. The study area falls in the toposheets Nos. 55F/9, 55F/10, 55F/6 which is mostly covered by alluvial plains comprising the mist fringing rock, the Deccan trap lava flows of Basaltic composition of Cretaceous-Eocene age. In order to evaluate the quality, 25 representative groundwater samples from shallow aquifers were collected from the study area. The collected water samples were analised by using the standard methods as proposed by APHA for drinking and agricultural purpose.

The result demonstrated that majority of the groundwater samples have nitrate concentration less than 50mg/l and 45 mg/l which is the upper mandatory limit as per water quality guidelines proposed by WHO and Indian Standards Specifications respectively However, few of the samples have nitrate concentration more than the permissible limit which indicates that they are fit for agriculture but not for the drinking purpose. Higher concentration of nitrate in shallow groundwater causes several disease such as methaemoglobinemia (blue baby syndrome), Alzheimer's disease, vascular dementia, netural tube defects and gastro-intestinal cancers.

The investigation also suggests that farmers of the study area should be motivated to adopt sprinkler, drip or trickle techniques for irrigation in place of flood irrigation. The farmers of the study area should use proper quality and quantity of fertilizers as per the requirement of the crops and as per manufacturing instructions.

Introduction

In recent years, the groundwater has become the major source of water supply for the drinking and irrigation sectors of many countries.Disposal of sewage wastes without treatment from urban areas, effluents from, increasing use of fertilizers, pesticides, insecticides etc. for better agricultural industries production are the principal cause of deterioration in the quality of natural waters. In order to achieve green revolution, the farmers are using high doses of nitrogenous fertilizers. At the same time, they are also applying flood irrigation. Such unscientific steps of the farmers have resulted in the ground water pollution by Nitrate, through return irrigational flows.

In the present study, an attempt has been made to evaluate the shallow ground waters of the study area, due to excessive use of fertilizers through return irrigational flows. The suitability of shallow ground water for drinking and irrigational purposes have also been worked out on the basis of water quality guide lines as proposed by WHO (2006), ISI (2004) and Ayers and Westcot (1994). The main purpose of the present study is to throw light on distribution of nitrate and possible cause of nitrate pollution in the area.

The present study covers an area of about 45 sq. kms. The area of present investigation falls on the Survey of India Toposheet Nos. 55F/9, 55F/10 and 55F/41. The area of present study is mostly covered with alluvium. Most of the study area is occupied by clay and clayey loam soils, commonly known as “Black cotton soils”.

Material and Methods

In order to know the chemistry of ground water quality, ground water samples from shallow aquifers were collected from the study area. In the present study, the standard procedures as suggested by Arnold *et al* (1998, APHA) have been followed in the chemical analysis. The nitrate concentration was determined by chromotrophic acid method using spectrophotometer at 410 nm, providing a light path of 1 cm.

Results and Discussion

In the area of present investigation, 25 ground water samples were collected from shallow aquifers. The ground water of the study area was found to be clear, colourless having no objectionable taste. The ranges of major cations and anions of ground water are given in **Table 1.** The nitrate concentration of ground water are presented in **Table 2.**

Frequency and percent frequency have been worked out separately as per drinking and irrigational specification and presented in **Table 3.**

Table 1 : Concentration of Major Cations and Anions in Groundwater of the Study area

Well No.	Name of Village	Temp. °C	pH	EC	TDS	CATION'S				T.H. as $CaCO_3$	ANION'S					
						Na^+	K^+	Ca^{++}	Mg^{++}		HCO_3	CO_3^-	Cl^-	NO_3^-	SO_4^-	PO_4^{---}
1	Phephartal	35.3	7.7	686	352	16	1.0	56	12	175	240	-	42	56	22	0.250
2	Hasulpur	35.0	7.5	659	335	16	1.4	40	13	200	134	-	41	30	27	0.578
3	Randhal	33.9	7.1	690	350	18	1.5	35	20	160	218	-	37	29	23	0.429
4	Khoksar	33.8	6.5	673	495	16	1.7	45	17	190	236	-	35	42	21	0.229
5	Kharkhedi	34.2	7.6	590	324	12	0.9	38	15	205	175	-	30	38	18	0.208
6	Mampa	33.7	7.6	747	339	18	1.8	41	14	125	218	-	34	56	19	0.206
7	Makrai	34.8	7.6	306	540	18	0.7	48	13	175	212	-	49	30	24	0.180
8	Pipalbaher	35.2	7.4	490	340	13	0.9	37	14	180	195	-	38	36	16	0.207
9	Dimawar	35.4	7.3	633	510	10	0.5	39	20	205	230	-	30	56	20	0.203
10	Bhainsadeh	34.9	7.5	748	499	20	0.6	44	25	185	264	-	49	50	12	0.172
11	Shivpur	33.8	7.8	427	650	16	0.4	40	8	150	218	-	28	58	29	0.570
12	Budhni	33.4	7.6	406	600	10	1.5	42	13	175	191	-	27	30	17	0.250
13	Pilikarar	35.4	7.5	795	403	12	1.7	35	16	205	203	-	38	42	14	0.283
14	Devgaon	35.3	7.2	636	800	10	1.1	38	10	185	180	-	30	45	20	0.254
15	Holipura	34.8	6.9	255	129	11	1.2	40	9	170	175	-	30	16	12	0.165
16	Mimor	32.7	7.4	905	457	22	2.3	30	12	165	161	-	39	55	28	0.183
17	Pathora	33.0	7.4	337	700	10	0.5	30	15	220	159	-	31	30	22	0.307
18	Ganjit	33.3	7.4	605	510	20	1.7	64	12	160	250	-	26	18	29	0.268
19	Aawali	33.4	7.5	740	450	15	1.3	60	15	180	210	-	20	35	28	0.302
20	Pangara	34.1	7.8	380	430	18	0.7	38	18	230	185	-	28	40	18	0.264
21	Dhankot	32.9	6.9	435	630	12	0.8	44	10	195	170	-	31	48	20	0.280
22	Chhidgaon	31.0	7.6	563	510	16	1.3	26	15	225	168	-	21	25	26	0.165
23	Mardanpur	35.8	7.5	747	378	16	1.8	32	11	165	162	-	28	32	26	0.237
24	Nehlai	34.4	7.4	474	540	15	1.6	28	20	195	200	-	33	50	12	0.180
25	Mathmi	34.8	7.5	396	480	13	1.2	35	18	176	209	-	33	54	16	0.209

Nitrogen is a vital plant nutrient and most of the crops have very large requirements of nitrogen. In order to meet the deficiency of nitrogen in soil, farmers are using nitrogenous fertilizers. A number of workers like Handa, 1977, 1983, 1986, 1987; Kaka, 1981; Handa et al., 1982; Kumar, 1983; Sehgal et al., 1989; Lunkad, 1994; Rao, 1998; Rao et al., 2006; Tamta et al., 1991; Parashar, 1994, 2001; Jhariya et al., 2012 from India and abroad have worked on the presence of high concentration of nitrate in ground water which generally varies from 3 mg/l to 1800 mg/l. They have reported and identified the possible source of nitrate.

Nitrate is considered as a second most common pollutant of ground water next to pesticides (Bachmat, 1994). These fertilizers ultimately tend to get oxidized to nitrates. A part of the added fertilizer leaches down to the saturated zone along with the downward percolating return irrigational flows and increases the nitrate concentration in the ground water and affects its quality. The use of sewage water for irrigation may also contribute small amount of nitrate to ground water. Handa (1983) mentions that exact sources of nitrate to ground water cannot be specified but the main source appears to be the input of nitrogenous fertilizers. As per the guidelines of WHO (2006), the nitrate concentration in drinking water should not exceed 50.0 mg/l and according to ISI (2004), the nitrate concentration should not exceed 45 mg/l, which is the maximum permissible limit. Regular intake of higher concentration of nitrate in food causes blue baby disease (Methaemoglobinemia) in babies. High doses of nitrates may directly affect the central nervous system, cardio vascular system and occurrence of goiter. Other health problems associated with nitrate toxicity includes oral, colon and rectum cancer or other gastrointestinal cancers.

In order to assess the ground water for drinking purpose, the physical and chemical characters of shallow ground water have been evaluated on the basis of water quality standards proposed by World Health Organization (2006) and Indian Standard Specifications for drinking water IS : 10500 (2004).

In physical characters, the ground water of the present area is colourless, odourless and has no objectionable taste. Thus, the ground water of the area at large is suitable for drinking purposes.

When the chemical characters of ground water

Table 2 : Nitrate Concentration in Ground Water of the study area

Well No.	Toposheet No.	Name of Nearest Village	Nitrate concentration in mg/l
1	55F/10	Phephartal	56
2	55F/10	Hasulpur	30
3	55F/10	Randhal	29
4	55F/10	Khoksar	42
5	55F/10	Kharkhedi	38
6	55F/10	Nanpa	56
7	55F/6	Makrai	30
8	55F/6	Pipalbaher	36
9	55F/6	Dimawar	56
10	55F/6	Bhainsadeh	50
11	55F/6	Shivpur	58
12	55F/9	Budhni	30
13	55F/9	Pilikarar	42
14	55F/9	Devgaon	45
15	55F/10	Holipura	16
16	55F/10	Ninor	55
17	55F/10	Pathora	30
18	55F/10	Ganjit	18
19	55F/10	Murjaha	35
20	55F/6	Pangara	40
21	55F/6	Dhankot	48
22	55F/6	Chhidgaon	25
23	55F/6	Mardanpur	32
24	55F/6	Nehlai	50
25	55F/6	Manjhil	54

(Table 2) are compared with the water quality guidelines of WHO (2006) and ISI (2004) as given in **Table 4**, it reveals that nitrate content from majority of ground water of the study area is well below the mandatory limit of 50 and 45 mg/l respectively, thus it is unpolluted water. All other cations and anions of ground waters are also well within the permissible limits of drinking water quality guidelines and thus they are suitable for drinking purposes.

However, 08 of the ground water samples from shallow aquifers have nitrate concentration more than 45 mg/l which shows the possible nitrate pollution in the area.

Majority of the area is occupied by clayey soil, which confirms that the fixation of NO_3 ions in clayey soil is possible. Continuous presence of high dose of nitrogenous fertilizers application along flood irrigation causing the leaching of NO_3 ions from soil profile to ground water regime is possible. If such a situation prevails for a longer period in the study area it is likely to cause the nitrate pollution. On the basis of the nature of nitrate distribution in the area it clearly demonstrates that it represents the point pollution, which are in the budding stage but it is likely to give high dimension with the passage of time and continuous use of nitrogenous fertilizers.

Ayers and Westcot (1994), proposed a modified water quality guidelines to assess the agricultural water quality. In the purposed guidelines presented in **Table 5,** they have classified and grouped the water quality into four categories namely salinity, water infiltration, Specific ion toxicity and miscellaneous effects. Each of the water quality problems has been further classified into the following three categories based upon the degree of restriction on their use.

1. None restriction category.
2. Slight to moderate restriction category.
3. Severe restriction category.

As per the guidelines of Ayer's and Westcot (1994), nitrate content up to 22.5 mg/l, cause no toxic effect, while concentration ranging from 22.5-135 mg/l causes slight to moderate toxicity and above 135 mg/l, nitrate concentration have severe restriction on irrigational use.

In the present study, the nitrate concentration varies from 16 to 58 mg/l. The frequency distribution of Nitrates in shallow ground water as shown in **Table 3**, which reveals that 5% ground water samples fall in the nitrate concentration range of up to 22.5 which reveals that this water may not be used for sensitive crops. **Table 3** further reveals that majority of ground water samples (95%) fall in the nitrate concentration ranges from 22.5 to 135 mg/l. As per the water quality guidelines proposed by Ayer and Westcot (1994), it clearly indicates that these waters have slight to moderate restriction with respect to sensitive crops. However, these water can be used for tolerant and semitolerant crops. As per the guidelines of Ayers and Westcot "Restrictions on use" does not indicate that the water is unsuitable for agricultural purposes but indicate that there may be a limitation of choice of crops or special management may be needed to maintain full production capability.

Table 3 : Frequency Distribution of Nitrate Concentration in Ground Water of the Study Area

S. No.	Nitrate concentration range in mg/l	Water classes	Frequency distribution	
			No. of Samples (F)	% (%f)
1	**As per drinking specification of WHO Recommendations Vol. I & II (2006)**			
	<50	Maximum Desirable	21	84
	>50	Polluted Water	04	16
		Total	**25**	**100%**
2	**As per drinking specification of Indian Standards of Institution (ISI, 2004)**			
	<45	Maximum Desirable	17	80
	>45	Polluted Water	08	20
		Total	**25**	**100%**
3	**As per Ayer's and Westcot Agricultural Water Quality Guidelines (1994)**			
	<22.5	None Restrictions	02	05
	22.5 to 135	Slight to moderate Restrictions	23	95
	>135	Severe Restrictions	Nil	Nil
		Total	**25**	**100%**

Table 4 : Water Quality Standards for Drinking Water Purposes

S.No.	Parameters	W.H.O. (2006)		I.S.I. (2004)	
		Highest Desirable	Maximum Permissible	Highest Desirable	Maximum Permissible
	Physical				
1	Turbidity (JTU units)	5	25	10	25
2	Colour, Hazen Units (on platinum cobalt scale)	5	25	5	50
3	Taste and Odour	-Unobjectionable-		-Unobjectionable-	
	Chemical				
1	pH	7.0-8.5	6.5-9.2	6.5-8.5	6.5-9.2
2	Total Dissolved Solids (mg/l)	500	1500	500	1500
3	Total Hardness as $CaCO_3$ (mg/l)	100	500	300	600
4	Calcium (mg/l)	75	200	75	200
5	Magnesium (mg/l)	<30*	150	30	100
6	Chloride (mg/l)	200	600	250	1000
7	Sulphate (mg/l)	200	400	150	upto 400**
8	Flouride (mg/l)	0.6-0.9	1.5	0.6-1.2	1.5
9	Nitrate (mg/l)	--	50	45	No relaxation

Table 5 : Agricultural Water Quality Guidelines (Ayer's and Westcot, 1994)

Potential Irrigation Problem	Units	Degree of Restriction on use		
		None	Slight to Moderate	Severe
Salinity				
(affects crop water availability)				
* Ec_w	mmhos/cm	< 700	700-3000	> 3000
* TDS	mg/l	< 450	450-2000	> 2000
Infiltration				
(affects infiltration rate of water into the soil. Evaluate using Ec_w and SAR together)				
SAR = 0-3 and Ec_w =		> 0.7	0.7-0.2	< 0.2
SAR = 3-6 and Ec_w =		> 1.2	1.2-0.3	< 0.3
SAR = 6-12 and Ec_w =	SAR	> 1.9	1.9-0.5	< 0.5
SAR = 12-20 and Ec_w =		> 2.9	2.9-1.3	< 1.3
SAR = 20-40 and Ec_w =		> 5.0	5.0-2.9	< 2.9
Specific Ion Toxicity				
(affects sensitive crops)				
Sodium (Na)				
* Surface Irrigation	me/l	< 3	3-9	> 9
* Sprinkler Irrigation	me/l	< 3	> 3	--
Chloride (Cl)				
* Surface Irrigation	me/l	< 3	4-10	> 10
* Sprinkler Irrigation	me/l	< 4	> 3	--
Boron				
Miscellaenous Effects	me/l	< 0.7	0.7-3.0	> 3.0
(affects susceptible crops)				
Nitrogen (NO_3 - N)	me/l	< 5	5-30	> 30
(Nitrate)	mg/l	< 22.5	22.5-135	> 135
Bicarbonate (HCO_3)	me/l	< 1.5	1.5-8.5	> 8.5
(Overhead sprinkling only)				
pH	Normal range 6.5-8.4			

Conclusion and Suggestions

On the basis of the quality of ground water of the study area, it is concluded that the concentration of nitrate in majority of the ground water samples are well below the mandatory limit. However, few of the samples have more nitrate concentration beyond the permissible limit. It is feared that these concentration unlikely to be augmented in due course of time by continuous use of Nitrogenous fertilizers.

On the basis of the hydrochemical studies, the following suggestions can be made:-

1. Organic fertilizers should be preferred over inorganic fertilizers (chemical fertilizers)
2. The farmers of the study area should be motivated to adopt sprinkler, drip or trickle techniques for irrigation in place of flood irrigation.
3. The farmers of the study area should use proper quality and quantity of fertilizers as per the requirement of the crops and as per manufacturing instructions.

4. The farmers must use the high nitrate water for irrigation as a substitute of nitrogenous fertilizers.

5. The ground water having the nitrate concentration below 22.5 mg/l should not be used for irrigation with respect to sensitive crops.

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References

Arnold, E. Greenberg; R. Rhodes Trussell; Lenore, S. Clesceri (1998): Standard Methods for the Examination of Water and Wastewater, 16th Edition. American Public Health Association (APHA), Washington, D.C. pp. 1-1268.

Ayers, R.S. and Westcot, D.W. (1994), Water Quality for Agriculture, Irrigation and Drainage, Paper No. 29 Rev. 1, FAO, Rome.

Bachmat, Y. (1994), Ground water as a part of the water system : In Ground water contamination and control. Ed. Uzoller, Marcel Dekkar, Inc., New York.

C.G.W.B. North Central Region Bhopal (1996) Reapparaisal Hydrogeological Surveys in Hoshangabasd Distt. M.P. Report.

Dar et al. (2010), Nitrate contamination in ground water of Sopore town and its environs, Kashmir, India, Arab J. Geosci. Vol. 3, pp. 267-272.

Environmental Planning and Coordination Organization (1992) Impact of fertilizers on Ground Waters and Soil Quality of Tawa and Barna Command Areas, M.P. Report.

Handa, B.K. (1977), Potassium and Nitrate ions as Indicators of Ground water pollution, Ind. Inst. Publ. Hlth. Engrs. India, pp. 45-58.

Handa, B.K. (1983), Effect of Fertilizer use on Ground water Quality in India, Proc. Int. Symp., Ground Water in Water Resources Planning, pp. 1105-1119.

Handa, B.K. (1983), The Effect of Fertilizer Use on Ground Water Quality in the Phreatic Zone with special reference to Uttar Pradesh, Proc. Seminar on Assessment, Development and Management of Ground water resources, Vol. II, C.G.W.B., Min. of Irrig. Govt. of India, New Delhi, pp. 415-425.

Handa, B.K. (1986), Pollution of Ground waters by Nitrates in India, BHUJAL NEWS, C.G.W.B., July-Sept., 1986, Vol. I, No. 3, pp. 16-19.

Handa, B.K. (1987), Nitrate content of Ground Water in India, Fertilizer News, July, 1987, Vol. 32, No. 6, pp. 11-29.

Handa, B.K., Goel, D.K., Kumar, Adarsh and Sondhi, T.N. (1982), Pollution of Ground water by Nitrate in Uttar Pradesh, IAWPC. Tech. manual, IX, pp. 95-103.

I.S.I. (2004), Indian Standard Specification for Drinking Water, IS : 10500, Second Edition.

Jain, R.K. (1993), Study of the effects of Excessive use of Fertilizers on the Quality of Ground water in Barna Command Areas Distt. Raisen (M.P.) Ph.D. Thesis (Unpublished), Barkatullah University, Bhopal.

Jhariya, D.C., Shandilya, Arun K. and Dewangan, Rakesh (2012), Nitrate pollution in the groundwater ground Sagar town, M.P., India, Int. conf. on Chem., Eco. and Evn. Sci. (ICEES-2012), Bangkok, pp. 151-154.

Kaka, Y.P. (1981), Nitrate Pollution of Ground Water in Southern and South-Western Haryana, India, Quality of Ground Water, Proc. Int. Symp. Studies in Environmental Sciences, Vol. 17, Elsevier Scientific Publishing Company, Netherlands, pp. 125-129.

Karanath, K.R. (1987), Ground water Assessment, Development and Management, Tata Mc Graw-Hill Pub. Comp. Ltd., New Delhi, pp. 1-720.

Kumar, Adarsh (1983), Pollution of Ground water by Nitrates in Uttar Pradesh, Proc. Seminar on Assessment Development and Management of Ground water Resources, Vol. II, C.G.W.B., Min. of Irrg. Govt. of India, New Delhi, pp 427-33.

Lunkad, S.K. (1994), Nitrate levels in ground water and increasing N-fertilizers consumption, Journal of Bhujal News.

Parashar, V.K. (1994), Study of Quality of Surface and Subsurface Waters and their Agricultural Utility in the Lower Alluvial plains of Narmada Valley between Khalghat and Harinphal Distt. West Numar M.P. Ph.D. Thesis (Unpublished), Barkatullah University, Bhopal.

Parashar, V.K. (2001), Excessive use of fertilizers and its impact on the Quality of Surface and Subsurface waters around Hoshangabad area, Project Report, UGC, NCR, Bhopal.

Prakash Rao, EVS and Puttanna, K. (2006), Strategies

for combating, Nitrate pollution Current Science, Vol. 91, No. 10, pp. 1335-1339.

Rao, N. Srinivasa (1998), Impact of clayey soils on nitrate pollution in the ground water of the lower Vamsadhara River basin, India, Hydrological Sciences-Journal-des sciences, Hydrologiques, Vol. 43(5), pp. 701-714.

Sehgal, V.K. et al. (1989), Nitrate pollution of ground water in Lucknow area, U.P. In : Proc. Int. Workshop on Appropriate Methodology for development and management of ground water resources in developing countries, Vol. 2, IBH-Oxford, New Delhi.

Tamta, S.R., Kapoor, S.L. and Goverdhan, T. (1991), Manurital Nitrate pollution of Ground Water in the Deccan Trap formation of Godavari Basin, Karnataka – Preliminary Case Study, BHUJAL NEWS, C.G.W.B., July-Sept., 1991, Vol. 6, No. 3, pp. 29-33.

W.H.O. (2006), International Standards for Drinking Water, World Health Organization, Geneva, vol. I and II.