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Human Health Risk Assessment for Nitrate intake in Lucknow, India

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Abstract: It is important to apply the methods to set the standard for drinking water quality and to conduct risk assessments since access to potable water resources exposes people to a variety of chemical pollutants, including nitrate. Drinking water with high nitrate levels can be harmful to health, especially for infants and pregnant women. The main objective of the present study was to determine the distribution levels of nitrate contamination in groundwater and its associated impact on human health risks in Lucknow India. For this 32 groundwater samples were collected randomly during April 2022. Nitrate concentration in groundwater samples ranged from 7 to 108 mg/L, with a mean value of 41.35 mg/L. The geographic information system (ArcGIS 10.7.1) was applied to mapping the nitrate concentration in groundwater resources of the studied area. About 43.75% of the groundwater samples are exceeding the permissible limits of nitrate (45 mg/l). Hence health risk assessment of nitrate has been carried out. Hazard quotient (HQ) values for male, female, children, and infants ranges from 0.14 to 2.07; 0.16 to 2.45; 0.17 to 2.63, and 0.16 to 2.53, respectively. The finding of data showed that HQ value was more than 1 in 53..125% of samples in groups of infants and children, 50% of samples for female, and 43.75% of samples in group of male.
Keywords: Health Risk Assessment, Hazard quotient (HQ), Nitrate contamination

I. INTRODUCTION

Safe drinking water is a basic need for good health, and it is also a basic right of humans. Fresh water is already a limiting resource in many parts of the world. Drinking water quality is a relative term that relates the composition of water with the effects of natural processes and human activities. Deterioration of drinking water quality arises from the introduction of chemical compounds into the water supply system through leaks and cross-connections. The quality of water is affected by an increase in anthropogenic activities and any pollution either physical or chemical causes changes to the quality of the receiving water body. Potential human health risk assessment, including noncarcinogenic and carcinogenic risks, has been considered a good and important method for determining health risks to humans. The level of nitrate in drinking water is an indicator of water quality. Based on the World Health Organization (WHO), nitrate is among the few contaminants found in drinking water that can cause very quick health problems. High levels of nitrate in drinking water can be harmful to both humans and animals. Environment Protection Agency (EPA) stipulated the maximum nitrate concentration in drinking water of 45 mg/L (USEPA 2013). Regular exposure to nitrate, one of the primary contaminants in groundwater reservoirs, can have a negative impact on health and increase the risk of methemoglobinemia (also known as "blue baby syndrome"), particularly in communities with small children. Therefore, monitoring of groundwater resources and use of methods for assessing the health risks of water pollutants should be required for programs that promote good health. The United States Environment Protection Agency (USEPA) defines the human health risk assessment as the systematic approach for estimating the likelihood of adverse health effects in the exposed population who may be susceptive to specific harmful substances in polluted ecological systems, such as water resources.

A. Study Area

Lucknow district situated in the state of Uttar Pradesh covers an area of 2528 sq. km. The area lies between North Latitude 26° 30‟- 27° 10‟ and East Longitude 80° 30‟- 81° 13‟. The shape of the district is like an irregular quadrilateral. Administratively, Lucknow district has been divided into 5 tehsils and 8 Community Development blocks viz., Bakshi Ka Talab, Chinhat, Gosaiganj, Kakori, Mal, Malihabad, Mohanlalganj, and Sarojani Nagar. The district is the capital of Uttar Pradesh and is well connected by railways, roads, and airways. The area is covered by younger and older alluvial plains. The younger alluvial plain lies all along the Gomti River and comprises active and older flood plains. The older alluvial plain occupies higher levels than the younger alluvial plain and is marked with natural levees, palaeochannels, and meander scars. The slope in the district is generally low with a slight high gradient along the Gomti River.

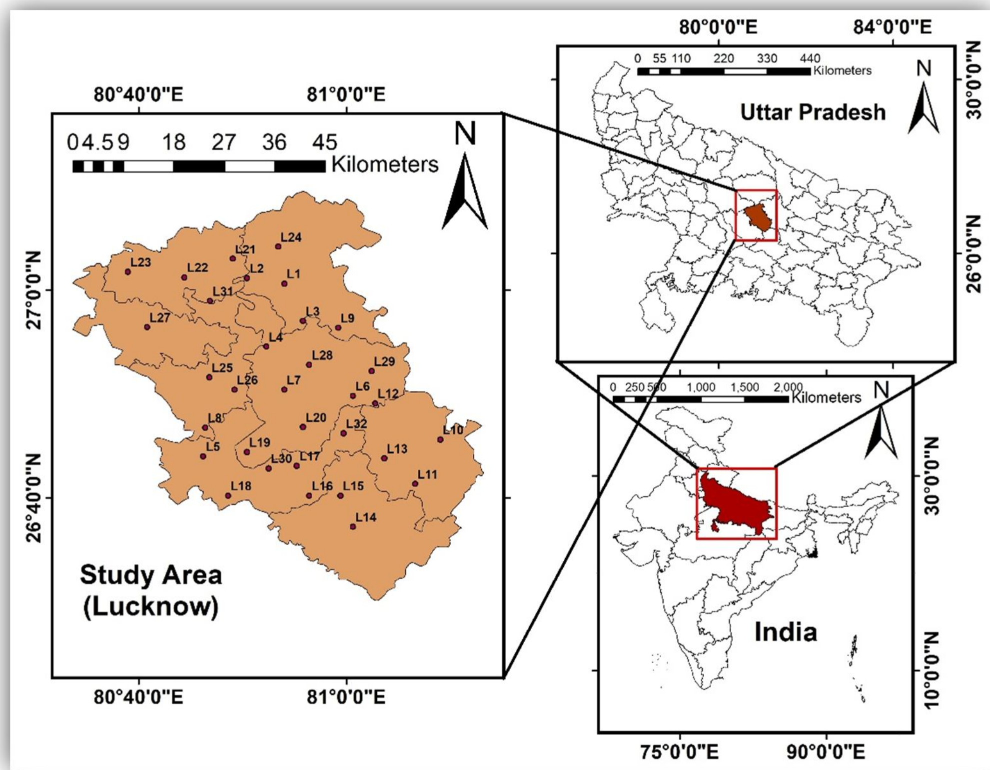

Fig. 1. Study Area Lucknow

II. MATERIALS AND METHODOLOGY

A. Data Descriptions

The groundwater samples were collected from 32 different location in the Lucknow district. The samples were collected in April month form bore/hand pump of study area. The samples were collected in acid-washed 1 litter polyethylene bottles to prevent unpredictable changes in characteristic as per standard procedures [3]. Each of the groundwater samples was analysed for nitrate. The nitrate concentration was measured with the help of Spectrophotometer standard method was used for the measurement of nitrate concentration suggested by APHA (American Public Health Association). the details of locations and concentration of Nitrate are given in table 2.

B. Human Health Risk Assessment

Groundwater quality has been steadily declining in recent decades as a result of numerous pollution sources such fertilisers and chemicals. And as a result, people are more aware of the risk to human health. In this new era, assessing health risks is essential. Health assessment insures and evaluates adverse human health effect on infants, children, female and male. The chronic daily intake (CDI) and hazard quotient (HQ) were calculated by following formulas:

$$\text{CDI} = \frac{\text{CPW} \times \text{IR} \times \text{ED} \times \text{EF}}{\text{ABW} \times \text{AET}} \quad \text{....... (1)}$$

$$\text{HQ} = \frac{\text{CDI}}{\text{RfD}} \quad \text{...... (2)}$$

Where CDI is the Chronic Daily Intake (mg/kg/day), CPW indicate nitrate contamination concentration in groundwater (mg/L), Ingestion rate (IR) 2 L/day for male and female, 0.78 L/day for children, 0.3 L/day infants. ED indicates exposure duration Years 40, 40, 12 & <1 for male, female, children, infants respectively. EF indicates exposure frequency is assigned, 365days/year for male, female, children and Infants, ABW denotes Average Body Weight of human body in kg 65 (male), 55 (female), 20 (Children), 8 (infants), AET denotes average exposure time Days, 14,600 for male and female, 4380 children and 365 infants.

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RfD indicates that reference of NO_3^- (1.6 mg/kg/d) were obtained from the database of Integrated Risk Information System (IRIS), and USEPA (2012). Hazard quotient value exceeding 1 is referred as adverse non-carcinogenic risk for human health, while HQ values less than 1 indicates acceptable limit of non-carcinogenic risk.

TABLE 1. PARAMETERS AND THEIR VALUES USED FOR HHRA COMPUTATION (USAEPA)

Parameter	Description	Male	Female	Children	Infants
IR	Ingestion Rate (L/day)	2	2	0.78	0.3
ED	Exposure Duration (years)	40	40	12	<1
EF	Exposure Frequency (days/year)	365	365	365	365
ABW	Average Body Weight (kg)	65	55	20	8
AET	Average Exposure Time (days)	14600	14600	4380	365
RfD	Reference Dose (mg/kg/d)	1.6	1.6	1.6	1.6

III. RESULTS AND DISCUSSION

Spatial map of nitrate concentration was made using GIS software (ArcGIS 10.7.1) shown in fig. 2. Which shows that about 44.5% of study area had more 45 mg/l of nitrate concentration. Nitrate concentration in groundwater samples ranged from 7 to 108 mg/L, with a mean value of 41.35 mg/L. Regular exposure to nitrate, one of the primary contaminants in groundwater reservoirs, can have a negative impact on health and increase the risk of methemoglobinemia (also known as "blue baby syndrome"), particularly in communities with small children. Hence health risk assessment of nitrate has been carried out. Hazard quotient (HQ) values for male, female, children, and infants ranges from 0.14 to 2.07; 0.16 to 2.45; 0.17 to 2.63, and 0.16 to 2.53, respectively. HQ value more than 1 indicates high risk. The finding of data showed that HQ value was more than 1 in 53..125% of samples in groups of infants and children, 50% of samples for female, and 43.75% of samples in group of male.

TABLE 2. NITRATE CONCENTRATION AND HAZARD QUOTIENT FOR FOUR GROUPS

Location	Longitude	Latitude	NO_3 (mg/l)	HQ Values			
				Male	Female	Children	Infants
L1	80.9	27.01	7	0.1346154	0.1590909	0.170625	0.164063
L2	80.84	27.02	20	0.3846154	0.4545455	0.4875	0.46875
L3	80.93	26.95	8	0.1538462	0.1818182	0.195	0.1875
L4	80.87	26.91	10	0.1923077	0.2272727	0.24375	0.234375
L5	80.77	26.73	58	1.1153846	1.3181818	1.41375	1.359375
L6	81.01	26.83	19	0.3653846	0.4318182	0.463125	0.445313
L7	80.9	26.84	17	0.3269231	0.3863636	0.414375	0.398438
L8	80.77	26.78	63	1.2115385	1.4318182	1.535625	1.476563
L9	80.99	26.94	11	0.2115385	0.25	0.268125	0.257813
L10	81.15	26.76	44	0.8461538	1	1.0725	1.03125
L11	81.11	26.69	43	0.8269231	0.9772727	1.048125	1.007813
L12	81.05	26.82	64	1.2307692	1.4545455	1.56	1.5
L13	81.06	26.73	34	0.6538462	0.7727273	0.82875	0.796875
L14	81.01	26.62	38	0.7307692	0.8636364	0.92625	0.890625
L15	80.99	26.67	52	1	1.1818182	1.2675	1.21875

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L16	80.94	26.67	72	1.3846154	1.6363636	1.755	1.6875
L17	80.92	26.72	78	1.5	1.7727273	1.90125	1.828125
L18	80.81	26.67	80	1.5384615	1.8181818	1.95	1.875
L19	80.84	26.74	11	0.2115385	0.25	0.268125	0.257813
L20	80.93	26.78	8	0.1538462	0.1818182	0.195	0.1875
L21	80.82	27.05	20	0.3846154	0.4545455	0.4875	0.46875
L22	80.74	27.02	12	0.2307692	0.2727273	0.2925	0.28125
L23	80.65	27.03	44	0.8461538	1	1.0725	1.03125
L24	80.89	27.07	54	1.0384615	1.2272727	1.31625	1.265625
L25	80.78	26.86	78	1.5	1.7727273	1.90125	1.828125
L26	80.82	26.84	10	0.1923077	0.2272727	0.24375	0.234375
L27	80.68	26.94	61	1.1730769	1.3863636	1.486875	1.429688
L28	80.94	26.88	8	0.1538462	0.1818182	0.195	0.1875
L29	81.04	26.87	74	1.4230769	1.6818182	1.80375	1.734375
L30	80.88	26.71	108	2.0769231	2.4545455	2.6325	2.53125
L31	80.78	26.98	53	1.0192308	1.2045455	1.291875	1.242188
L32	81	26.77	64	1.2307692	1.4545455	1.56	1.5

TABLE 3. HQ RANGE OF SAMPLES FOR FOUR GROUP

Human	Range of HQ	Health risk	No. of samples	% of samples
Male	>1	High risk	14	43.75
	<1	No risk	18	56.25
Female	>1	High risk	16	50
	<1	No risk	16	50
Children	>1	High risk	17	53.125
	<1	No risk	15	46.875
Infant	>1	High risk	17	53.125
	<1	No risk	15	46.875

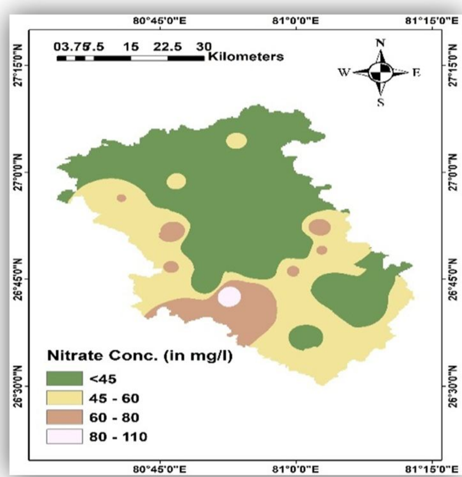

Fig 2. Spatial map showing Nitrate concentration

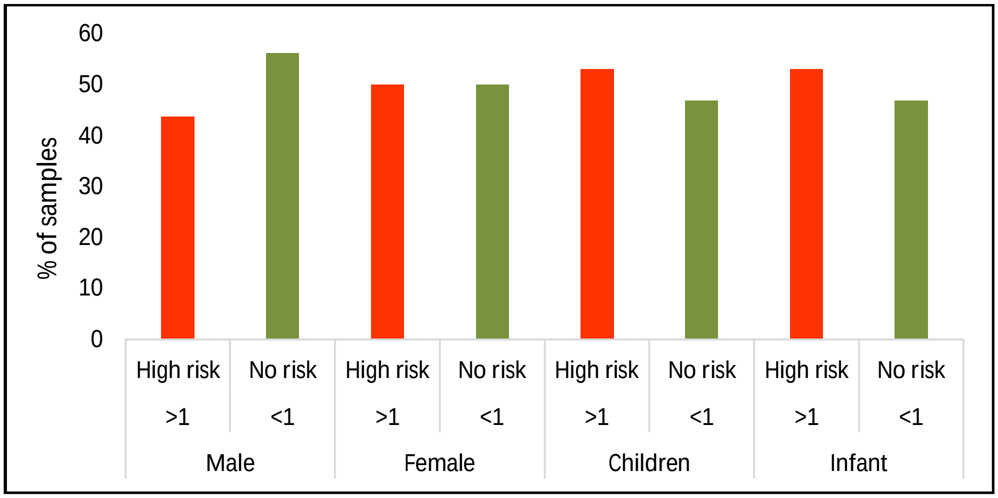

Fig. 3 Frequency distribution of HQ of four groups for nitrate concentration

IV. CONCLUSIONS

The data of present paper revealed that the nitrate concentration in 43.75% of groundwater samples exceeding the maximum permissible limits (45 mg/L) according to world health organization (WHO) guidelines. The study's conclusions show that all four groups—infants, kids, women, and men—are exposed to nitrate risk (HQ>1). High nitrate concentration in drinking water causes health risks on human body like methemoglobinemia in infants and stomach cancer in children. The findings of this study reveal the all the four groups i.e. infants, children, female and male are exposed to nitrate risk (HQ>1). Health risk assessment revealed that male, are less prone to risk than female. Hence proper precautionary measures have to be taken to control health risk in this area.

V. ACKNOWLEDGMENT

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