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GROUNDWATER POLLUTION DUE TO NITRATE, ASSOCIATED HUMAN HEALTH IMPACT AND POTENTIAL HEALTH RISK ASSESSMENT

Abhishek Singh[1], Virendra Verma[2], Brijesh Kumar Yadav[3], Vinod Kumar Chaudhary[3]*

[1]Department of Mathematics and Statistics, Dr. Rammanohar Lohia Avadh University, Ayodhya, India
[2]Department of Medicine, Rajarish Dasrath Autonomous State Medical College Society Ayodhya, Faizabad, India
[3]Department of Environmental Sciences, Dr. Rammanohar Lohia Avadh University, Ayodhya, India

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ABSTRACT

Level of nitrate in our water bodies is increasing at a very fast rate not only in India but throughout the globe. The reason for increase is related to over use of fertilizers and discards from the cities and industries. Consumption of high concentration nitrate water leads to several health disorders in humans including; methemoglobinemia, thyroid, cancer, blood pressure, diabetes etc. In order to prevent from the ill effect of nitrate various research organisations around the globe had established maximum permissible limit that can be allowed in water supply as above which required steps should be performed to remove the excess concentration. In order to prevent the human being from the further ill effects on exposure to nitrate further risk assessment can be performed.

Keywords: Methemoglobinemia; Risk Assessment, Groundwater pollution, Cancer, Thyroid.

INTRODUCTION

Water is considered as one of the vital resources required for existence of any form of life on planet earth. Nearly 70.9% of the Earth's surface is covered with water out of which majority is found in oceans (96.5%) while groundwater covers 1.7% and rest is present in form of glaciers and in air in the form of clouds and vapor etc. (Gleick, 1993). Out of the total availability of water resource only 2.5 is considered as fresh. In last few decades availability of safe drinking water has improved a lot but still enormous number of people (nearly one billion) are still missing it. According to a research performed by Kulshreshtha it had been reported that nearly half of the population around the globe will be facing problems related to water by 2025 (Kulshreshtha, 1998). In recent years, crisis of water in various parts of the world has become one of the important issue and hence it had gained enormous attention form the researchers around the globe in order to find and develop the sustainable sources of fresh water (Mossad and Zou, 2013). Water Pollution is becoming one of the major reason for health disorder among humans and nearly 2.3 billon people are facing some sort of illness due it (UNESCO, 2003; Kalal et al., 2021). According to reports by international organisations, it had been founded consumption of polluted water is cause of death to more than 2 million people in developing countries (Azizullah et al., 2011).Groundwater, because of its purity, is considered as one of most important source of portable water. With advancement in techniques and excessive use of nitrogenous fertilizers in the crop field's quality of groundwater has deteriorated significantly (Roo1980; Schepers at al., 1984). The level of nitrate in water is not only elevated due to excessive use of fertilizers but also due to improper disposal of municipal and

*Corresponding author: *vinodkrchaudhary@gmail.com*

industrial waste. These anthropogenic activities cause several serious environmental issues including; biodiversity threats, eutrophication, health issues in animals and humans (Prakash and Verma, 2022). Growth of algae and other aquatic plants will prove to be disastrous to fish and other aquatic species (Camargo and Alonso, 2006). Nitrate, because of high solubility and low retention in soil, it filters to subsoil and hence mixing with the groundwater (Stevenson, 1986).High level of nitrate in groundwater is mainly due to enormous waste generation due to urbanization and industrialisation (Handa, 1983). Consumption of groundwater having high nitrate concentration leads to several health disorders like methemoglobinaemia in child and cancer in adults mainly stomach (Fewtrell, 2004; Pennington, 1998; Chiu et al., 2007).In order to manage and control the ill effects due to presence of excessive nitrate in groundwater various regulatory bodies around the globe had established limit of nitrate concentration in water. The maximum allowable limit of nitrate recommended by India, WHO, USEPA, EU, Australia, and South Africa are 45, 50, 45, 50, 50, and 20 mg/l respectively (BIS: 10500, 2012; WHO, 2008; USEPA 2009; EU 2007; National Health and Medical Research Council, 2011; Masukume et al., 2011). Removal of nitrate from the water is little bit difficult by conventional water treatment methods as it show poor precipitation and adsorption tendency mainly due to higher stability and solubility (Islam et al., 2010). In recent years various technologies employed for removal of nitrate from water includes; electrodialysis, adsorption, denitrification, ion exchange, reverse osmosis, and biological etc. (Canter, 1997, Soares, 2000, Schoeman and Steyn, 2003, Öztürk and Bektaş, 2004; Zhan et al., 2011, Bhatnagar and Sillanpää, 2011, Abou-Shadyet al., 2012). Adsorption of nitrate, because convenience, operation, cost effectiveness, simpler design and easy and cheap regeneration techniques, makes it one of the most attractive method for treatment of contaminated water (Khan et al., 2011).

Nitrate Associated human health Impact

Nitrate in humans can enter via dermal, oral or by inhalation. The presence of nitrate above permissible limit may lead to several health disorders. The effect of nitrate may be acute, intermediate or chronic. Presence of nitrate above permissible limit in infants leads to methemoglobinemia disease. In this consumed nitrate gets converted in to nitrite in the mouth by bacteria that further binds with haemoglobin and forms methemoglobin, resulting in the reduction of the oxygen carrying capacity of the blood. This becomes life threating if the methemoglobin presence becomes more than 10 % (Ward et al., 2005; Greer et al., 2005). Nitrate consumption above permissible limit may also lead to pregnancy failure including prematurity, neonatal deaths, low birth weight and fetal death etc. (Ward et al., 2005). Ingestion of nitrate in higher concentration may leads to thyroid, stomach cancer, childhood diabetes, disease related to respiratory tract, blood pressure, myocardial infarction and heart failure etc (Ahluwalia et al., 2016; Kapil et al., 2015; Omar et al., 2015; De Groef., 2006; Van Maanen et al., 1996).

Exposure assessment

The main importance of exposure assessment is to develop exposure assessment model for predicting the risk associated with it by using factors like exposure pathway, exposure age group, exposure magnitude and frequency and the duration for which the person is exposed to the contaminated system. The recommended pathway of exposure for environmental medium incudes; air, water, soil, and food. Either Ingestion or dermal absorption are the major pathway via which nitrate reaches to human body. Therefore, in order to analyse the risk of exposure there is need to determine the daily absorbed dose (DAD) and chronic daily intake (CDI) in a human by using certain formulas.

DAD is used to find the quantity of the potentially health hazardous chemical across the skin per day in to the human body and it is calculated in mg/kg per day. The formula used for this was provided by USEPA [USEPA 2004].

$$DAD = \frac{C_w \times K_i \times SA \times EF \times ED \times EV \times CF}{BW \times AT}$$

Where,

DAD= daily absorbed dose (mg/kg per day)

Ki= Dermal adsorption parameter (cm/h)

SA=skin surface area available for contact (cm2/event)

EF=Exposure frequency (days/year)

ED = Exposure duration (year)

EV= bathing frequency (times/day)

CF=conversion factor (L/cm3);

BW= average body weight, (kg)

AT= averaging time (days) (AT = EF x ED)

CDI, an important aspect for estimating the potential risk by the contaminants discarded in the environment on human body by drinking of water. Formula given by USEPA, can be used for the calculation of CDI [USEPA 1991].

$$CDI = \frac{C_w \times DI \times EF \times ED}{BW \times AT}$$

Where,

CDI= chronic daily intake (mg/kg per day)
CW = contaminant concentration in the water, (mg/L)
DI= daily intake of water (L/day)
EF= Exposure frequency (days/year)

ED= average exposure duration in a lifetime, (Year)
BW= average body weight, (kg)
AT = averaging time (days) (AT = EF x ED).

Risk characterization

Risk Characterisation is one of the utmost important and last step in health risk assessment. The data obtained by using the previous steps are used to analyse the overall situation so that a better conclusion with clear information can be obtained and hence can be helpful in decision making [Fowle and Dearfield, 2000].

The hazard quotient is calculated to represent the possible hazard of nitrate in water (both by drinking water and by dermal contact pathways) for human health risk assessment. The following formula is used for the calculation of hazard quotient

$$HQ_0 = CDI / RfD_0$$

Where,0*HQ*= Noncarcinogenic hazard quotient of the drinking water pathway, unitless
CDI= Chronic daily intake (mg/kg day)0*RfD*= Nitrate reference dose of the drinking water pathway (mg/kg day).

Hazard quotient formula for dermal contact is given as;

$$HQ_d = DAD / RfD_d$$

Where,

HQ_d= Non-carcinogenic hazard quotient of the dermal contact pathway, unitless

DAD= Daily absorbed dose (mg/kg day)

RfD_d= nitrate reference dose of the dermal contact pathway (mg/kg day)

The overall hazard quotient for health risk assessment can be calculated by linear superposition of HQ_O and HQ_d, which can be shown as;

$$HD = HQ_0 + HQ_d \; HD = HQ_0 + HQ_d$$

Where, HD is the total hazard quotient for the human health risk assessment, and it unit less.

CONCLUSION

With rapid industrialisation, urbanisation and population overutilization of nitrogenous fertilizers and disposal of municipal and industrial waste had increased immensely. This became one of the most important reason for increase in the concentration of nitrate in groundwater. Consumption of the water with high amount of nitrate leads to several health related issues in human beings. Hence various international organisation around the globe had established maximum allowable limit of nitrate in water so that on consumption it would pose no further health effect. Health risk assessment had been being explained in order to calculate the possible health impact in human being based on dose, route of exposure and contact duration. So that necessary action should be taken in order to prevent from ill effects on exposure.

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