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Hazard Quotient, Odd Ratio and Relative Risk: As the methods for assessment of health risks

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Abstract: Aim of the work was to investigate the pollutants level specially Nitrate- N in the groundwater and compare the obtained results with WHO standard. Groundwater sample were collected from sixty wells consists of thirty cancer patients well as case and other thirty as control within 100 m distance from highly affected three areas of oesophagus and stomach cancer. Questionnaire was used for case- control study. The determined values expressed by hazard quotient indicate that the water pollutants and their concentrations do not exceed unity. Chunnakam was shown the high odds ratio which was greater than one. But in relative risk was greater than one in all the selected three areas. Ingestion with water is the main pathway for nitrates than the vegetables in areas where groundwater with high nitrate content.

Keywords: Hazard Quotient, Odd Ratio, Relative Risk and Health risks

Introduction

Pollution problems in Sri Lanka are more serious proportions as urban communities grow, industry expands, rural areas develop, farmers intensity agriculture and mining and other development programs unfold. Groundwater is a potential source of a safe water supply for drinking. Contamination of drinking water by nitrate is evolving public health concern since nitrate can undergo endogenous reductions and can form nitroso compounds, which are carcinogens. There were past history of contamination of nitrate- N in drinking water and high incidences of cancer in Jaffna Peninsula (Jayakumarn, 2008). Hence the objective of this study was selected as determination of nitrate – N and nitrite concentration in groundwater at high risk area, and health risk assessment link with the esophagus and stomach cancer.

Nitrate contamination is the major factor which significantly polluting the groundwater today. In many countries nitrate levels of groundwater has been increased significantly due to extreme use of nitrogenous fertilizers. Nitrogenous compounds in well water for drinking are considered as a possible risk factor for oesophageal cancer (Zhang, 1996). Nitrate is potentially hazardous when present at sufficiently high concentrations in drinking water. Nitrates which could be converted into carcinogenic substances such as nitrosamines within the body are of importance in the carcinogenesis of esophageal and stomach cancers (Dissanayake, 1988). An ecologic study done on nitrate in municipal drinking water and cancer incidence in Trnava district, Slovakia supports the hypothesis that there is a positive association between nitrates in drinking water and cancer (Gulis *et.al*., 2002). According to Jeyakumaran, (2008) that there is "possible cancer hazards from pesticide residues in food have been much discussed and hotly debated in the scientific literature".

Materials and Methods

Selection of location for water sampling

Out of all cancer patients history sheet, Oesophagus and stomach cancer patients were separated based on the guidance given by the Oncologist of Jaffna Teaching hospital. Then the patients were grouped according to Divisional Secretariat. Thirty patients were selected randomly from three Divisional Secretariats (ten from each) such as Jaffna, Vadamaradchchi and Chunnakam based on highly affected area and groundwater samples were collected from selected thirty wells. Another 30 wells were selected from the neighboring area of within 100 m distance from cancer patients well as control. All together 60 wells were selected for sampling.

Collection of data for case - control study

A questionnaire was used to collect the information of patients and their family members. The personal information of cancer patients were taken from close relatives in their families due to ethical reasons.

Collection of water samples

Groundwater samples were collected at 20 cm depth from the water surface of the well. Monthly samples were taken during the wet period of December 2010 to February 2011. Cadmium reduction method was used to analyze NO_3 - N and NO_2 - N and NH_4^+ were not considered for measurement since the compounds were no stable in water and oxidized.

Calculation of Odd Ratio (OR), Relative Risk (RR) and Hazard Quotient (HQ)

Risk assessment is the processes of estimating the probability of occurrence of an event and the probable magnitude of adverse health effects over a specific time period. Relative risk is a ratio of probabilities. It compares the incidence or risk of an event among those with those who were not exposed. Case-control studies reveal the relationship between exposure and disease by comparing people with the disease (cases), with people without the disease (controls). The measure of case-control study is called odd ratio, or relative odds (Joseph and Thomas, 2007).

Odd ratio is the ratio between the odds exposure in the case group to the odds of exposure in the control group. Due to the consumption of nitrate contaminated water relative risk to human was calculated using the equation RR =PEC/PNEC Where; PEC –Probable of exposure concentration and PNEC –Probable of non- exposure concentration. If the relative risk greater than 1, the risk will be greater in exposed persons than non-exposed and there is a positive relationship with the exposure parameter. If the relative risk of less than 1 that indicates there is no relationship between the risk factors and the cases (Joseph and Thomas, 2007)

The estimated uptake of a potential toxin by the human body through contact with a contaminant is estimated using the chronic daily intake (CDI). The CDI value indicates the quantity of chemical substance ingested through body per kilogram of body weight per day (Gao *et al*., 2012 and Pawelczyk, 2012). Potential noncarcinogenic risks for exposure to contaminants of potential concern were evaluated by comparison of the estimated contaminant intakes with the reference dose.

$$CDI = \frac{(C \times IR \times ED \times EF)}{BW \times AT}$$

In which C = Pollutants concentration (mg/l)
IR = Drinking rate (l/day)
ED = Exposure duration (year)
EF = Exposure frequency (d/year)
BW = Average body weight (Kg)
AT = Average exposure time (days)

The above said parameters were taken from the questionnaire survey.

Hazard quotient (HQ)

$$HQ = \frac{(CDI \times 10^{-6})}{Rfd}$$

Rfd = Reference dose (mg/kg/day) value for NO3- N as 3.7 mg/kg/day

Analysis of dietary intake of Nitrate

Average nitrate content in mg/Kg on fresh weight basis were analyzed by taking the samples from local Thirunelvelly market. Results revealed that the content

of nitrate in Amaranthus as 162 mg/Kg, Brinjal 152 mg/Kg, Cabbage 392 mg/Kg, carrot 391 mg/Kg, Onion 65 mg/Kg, Radish 332 mg/Kg and Tomato 177 mg/Kg (Sivasakthy and Gnanavelrajah, 2010). The questionnaire survey was carried to estimate the consumption of above said vegetables among the consumers. The nitrate content of rice was taken from the reference.

Results and Discussion

Description of case

The total treated cancer patients were 2300. Out of which, oesophagus and stomach cancer patients were 7% (159), in which male patients were higher than the female patients except in Islands and Jaffna. Based on the age, all treated patients were greater than 50 years. The figure 1 shows the average concentration of nitrate – N in groundwater for thirty case and control patients well. In some cases, the person who had consumed the drinking water with high nitrate-N suffered by oesophagus cancer. But in some cases long term exposure of nitrate with drinking water even less than recommended level of 10 mg NO_3-N/L may induce the endogenous formation of nitrosamines. Out of tested thirty patient case wells, only two wells were greater than 10 mg/l of WHO recommended wells. The study by Forman *et al.*, 1985 in United Kingdom had shown that an inverse relationship where instances of stomach cancer are highest in areas where the groundwater concentration of nitrate is lowest and vice versa.

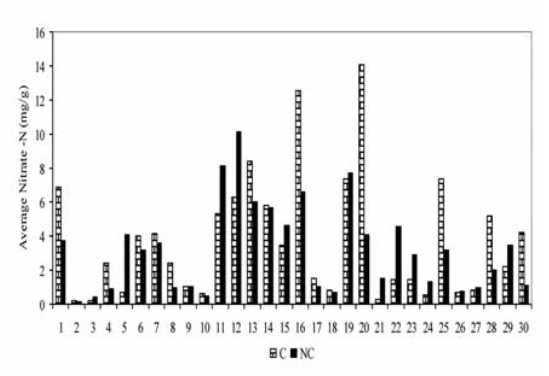

Figure 1: Average concentration of nitrate-N in case and control wells

Risk Analysis

According to table 1 odds ratio is high in Chunnakam. Relative risk also greater than one in Chunnakam. If the odds ratio is greater than one, there are a greater proportion of exposed subjects in the case group than in the controls, and a positive association exists between the risk factor and disease. When odds ratio increase, association between risk factor and disease also get strong (Joseph and Thomas, 2007).

Table 1:
Odd ratios of study area

Area	Case	$[NO_3^-$-N] ≥ 10mg/L	Control	$[NO_3^-$-N] ≥ 10mg/L	Odd ratio
Vadamaradchi	34	0	38	0	0
Chunnakam	39	3	33	2	1.3
Jaffna	29	0	45	0	0

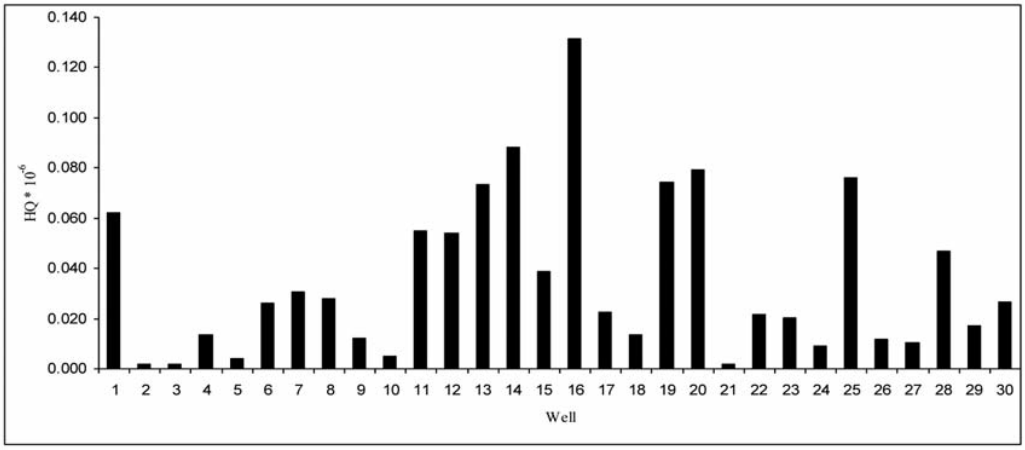

Figure 2: Noncarcinogenic oral risk value for groundwater

Table 2:
Relative risk of study areas

Area	PEC	PNEC	RR
Vadamaradchi	2.52	2.61	1.17
Chunnakam	6.1	6.00	1.02
Jaffna	2.61	2.10	1.24

Chunnakam was shown the high odds ratio which greater than one which express there may be positive association between risk factor and disease but we cannot confirm that without detailed studies of epidemiology. Chunnakam is one of the intensive agricultural areas of the peninsula. In case of relative risk, it was greater than one in three selected areas. If the relative risk was greater than 1 that indicates there is a relationship between the risk factors and the cases.

Figure 2 shows hazard quotient values for selected thirty case wells. The hazard quotient assumes there is a level of exposure below which it is unlikely for even sensitive population to experience adverse health effects. There may be a concern arising for the potential noncarcinogenic effects if the HQ exceeds 1 X 10^{-6}(Unity). The results showed that the levels of noncarcinogenic oral risk ranged from 0.01 to 0.13 X 10^{-6} .

The World Health Organization International Agency for Research on Cancer (IARC) ranked nitrates and nitrites high on the priority list for upcoming review of possible carcinogenicity of ingested nitrates and nitrites. Analysis of local vegetables available in local market revealed that none of the tested vegetables samples had nitrate content above the risk level of 3.7 mg/Kg body weight/day when consumed alone (Sivasakthy and Gnanavelrajah, 2010). According to the Questionnaire survey, the total intake of nitrate from the vegetables was 200.9 mg/day and from the water it was 144 mg/day. Hence the total consumption of nitrate was 344.9 mg/day. If the average body weight is 60 Kg, possibility of average level of exposure is 222 (3.7 * 60) mg/kg/day. Hence consumption of nitrate was high than the average level of exposure. This was due to consumption of high nitrate content water than the vegetables. Further research with a detailed analysis of dietary nitrate is needed to more precisely define the relation between nitrate and stomach cancer.

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