Nitrate Burden in Drinking Water in Northern Punjab, Pakistan: A Challenge for Public Health

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Introduction

One of the major worldwide problem is the availability of safe drinking water, which people are going to face in future. In Pakistan people get drinking water from various sources. In cities it comes in the form of piped water and in the villages hand pumps, wells, open tanks filled with canal and river water directly are the major sources of drinking water. The pipes carrying drinking water mostly go side-by-side with sewerage system. Therefore, back pressures; pipes leakages and improper cleaning of the overhead water tanks are the major sources of the drinking water contamination. On the other hand adverse sanitary conditions and the faulty methods of drinking water preservation in the villages invite all sorts of bacteria, roughage and every possible contaminant for the water, thereby making drinking water polluted [1].

Nitrate may be widely present in substantial quantities in soil and natural waters. High concentrations often indicate direct nitrate discharges, from non point sources (e.g. fertilizer uses), or pollution by organic compounds. In the later case nitrate is the end product of microbial oxidation of organic nitrogen and ammonia (nitrification). Nitrate by itself is non-toxic, but when nitrates are ingested they may be reduced to nitrite by bacteria generally found in the mouth and intestines of human being. Some studies suggested that elevated nitrate concentrations in water are associated with both genotoxic and cytogenetic effects. These effects were reflected in an increased concentration of HPRT variant frequencies and sister chromosome breaks or exchanges in people exposed to high nitrate concentration in water [2,3].

Nitrate is a major component of human and animal wastes, and the occurrence of abnormally high concentrations of nitrate suggests possible pollution of water resources. Nitrate is usually one of the most prevalent forms of nitrogen in water because it is the end product of the aerobic decomposition of organic nitrogen. Nitrate from natural sources is attributed by oxidation of air nitrogen by bacterial and to the decomposition of organic material in the soil. Moreover, in agriculture some fertilizers are direct source of nitrates e.g., calcium nitrate $Ca(NO_3)_2$, ammonium nitrate NH_4NO_3 etc. a part of this material will leach into the soil, come in contact with ground water and contaminate it [4]. In polluted waters, however, levels from 50 to a few hundreds mg L^{-1} have often been reported which exceeded the WHO guideline for drinking water of 50 mg L^{-1}. The main objective of this study is to evaluate level of nitrate contaminations in different sites so as to avoid from potential human health risk.

Results and Discussion

The results of ground water samples collected from Northern area of Punjab, Pakistan (Gujarat, Jehlum, Chakwal and Sargodha districts) are shown in Table-1. In districts Gujarat, Jehlum, Chakwal and Sargodha, 60, 33, 30 and 84% samples were within the permissible limits of WHO standards and 40, 67, 70 and 16% samples exceeds the WHO [5] drinking water nitrate limits respectively. These samples were also above the US EPA and EU values of drinking water limits (Table-2). The results showed that the situation in the region is devoid of sewage system. Septic tanks, soaking pits and solid wastes dumps are common in these areas. The excessive use of nitrogen fertilizers may also increased nitrate content in ground water. The leachates from agricultural fields, garbage dumps, intensive agricultural production and

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Table-1:Nitrate, Nitrate-N in Different Areas of the Northern Punjab, Pakistan

District	Drinking water sources	No. of samples	Total samples	Nitrate, mg L^{-1}	NO_3–N Range mg L^{-1}	NO_3 range mg L^{-1}
Gujarat	Motor pump	2	15	19.04	0.056-15.48	0.25-68.6
	Hand pump	6				
	Tube well	4				
	Wells	3				
Jehlum	Motor pump	3	15	13.03	0.56-18.54	0.25-82.24
	Hand pump	5				
	Tube well	5				
	Wells	2				
Chakwal	Motor pump	3	20	74.95	0.079-72.55	0.35-21.42
	Hand pump	12				
	Tube well	3				
	Wells	2				
Sarghodha	Motor pump	3	18	8.30	0.038-10.39	.014-46.06
	Hand pump	6				
	Tube well	6				
	Wells	3				

Table-2:Drinking Water Standards for the United States and the European Union

Nitrogen compound	United States (US, EPA)	European Uniion (Rabalais, 2002)
Nitrate		
(as nitrate)	44 mg L^{-1}	50 mg L^{-1}
(as nitrogen)	10 mg L^{-1}	11.2 mg L^{-1}
Nitrate		
(as nitrite)	3.2 mg L^{-1}	1.5 mg L^{-1}
(as nitrogen)	1.0 mg L^{-1}	0.5 mg L^{-1}

Ref. [9].

shallow water table also increase the nitrate contents in the ground water of northern Punjab.

The practice of septic tanks and soaking pits may be replaced by proper sewage system. The use of nitrogen fertilizer should be restricted keeping in view the uptake of nitrogen by crops so as to avoid excess of nitrogen in the soil. Restrict disposal of manure and wastes from agricultural run off into surface water and on land especially where the groundwater level is low. There is a need to apply fertilizers and manure in relation to the essential requirement of the crops and taking into account the available nitrogen already present in the soil. More detailed investigations are required and samples period should cover all the four seasons. A healthy survey in the region should be carried out in details by a team of experts including medical doctors and environmental specialists.

Experimental

Water Sampling

In this contest, a survey was conducted to collect the water samples for assessing the ground water quality in districts Gujarat and Jehlum, 15 water samples (in duplicate) from each site were collected for analysis. In Chakwal and Sargodha 18 and 20 water samples (in duplicate) from different sites were collected respectively. The fieldwork was associated with collection, transport and preservation at 4°C or addition of $HgCl_2$ (20-40 mg L^{-1}) of samples in one-litter clean polyethylene bottles according to ASTM standards methods [4]. Maximum time between sampling and analysis was 1-7 days. In each district two samples were taken from each site, which serve as a control for comparison with conditions presently suffering from human activities.

Nitrate Assay

For the determination of nitrates conventional, titrimetric, colorimetric [6] and electrochemical [7] methods are available. In this study the determination of NO_3 was carried out spectrophotometerically. The method was quite easy, sensitive, accurate, cheap and applicable. The method of determination is based on the addition of a chloroform solution of brucine alkaloid and sulfuric acid to the sample to be tested, the intensity of which is proportional to the amount of nitrate ion present in the water. The intensity of the color was measured at 470 nm [8].

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