Nitrate and Nitrite Contamination of Sub-Surface Water in Some Areas of North West Frontier Province (N.W.F.P) Pakistan

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Summary: Over the past few years, nitrate and nitrite contamination of sub-surface water samples from Peshawar, Charsadda, Mardan and Nowshera districts of NWFP has been studied. In all the areas under study, nitrate concentration of sub-surface water was found to be below WHO approved limit of 45 mg/L. Whereas, Peshawar city area after 1987 showed a decreasing level of nitrate contamination of sub-surface water, it appeared to be on the increase in water samples from the outskirts of Peshawar along Pehsawar-Charsadda road. No uniform increasing or decreasing patterns of nitrate contamination were observed for water samples from cantonment, University and Hayatabad, areas of Mardan, Charsadda and Nowshera under study. The nitrate contamination of sub-surface water appeared to be due to both the agricultural activities as well as human and animal wastes. A few sub-surface water samples from Peshawar city, Mardan and Nowshera areas indicated high concentration of nitrite, which is alarming in view of the earlier reports showing absence of nitrite in water samples from these areas. However, since 1993, nitrite presence has not been detected in sub-surface water samples from all the areas under present investigation.

Introduction

Aquatic pollution in Pakistan is mainly due to siltation, increasing agricultural activities, rapid industrial development, poor sanitation and unhygenic practices by the general public [1,2]. A number of diseases are caused by consuming water of poor quality [3,4]. According to a "Community Health Study" report, thirty percent of all reported cases of illness and fourty percent of deaths in our country were due to water borne diseases [2].

Poor quality of water for human consumption may be either due to the presence of harmful bacteria or lack/overabundance of certain chemical entities [5]. Nitrates and nitrites are considered to be the most important parameters for ascertaining the suitability of water for drinking purposes. Toxicity and physiological effects of excess of nitrates and nitrites in water are well-known and have been reported in many reports and publications. Cyanosis among infants under three months of age has long been known to be caused by high nitrate contents in water [6]. Several cases of infants methaemoglobinemia (causing impairment of oxygen transport) with death rate of 7-8% of the affected infants have occurred in America, Canada and Europe [3]. Nitrites, formed mostly due to reduction of nitrates and/or oxidation of ammonia, are throught to be the etiologic agent of methaemoglobinemia. In vivo and in the natural environment, nitrous acid formed due to nitrites, react with amines and amides, producing highly carcinogenic nitrosoamines [7].

In NWFP more than half of six million population of Peshawar, Mardan, Charsadda and Nowshera districts have no access to clean drinking water. The remaining half draw their water from some 590 tube-wells [8]. Most of the wells are shallow and are liable to contamination from the neighbouring sources such as latrines, drains cesspools, soakage etc. In many parts of the world, nitrate-nitrite contamination of underground water has been delineated to extensive use of nitrogeneous fertilizer or leaching from open disposal and storage of agricultural, animal and human wastes [9-12].

In Punjab, the nitrate concentration of underground water in 1967 was generally found to be less than 3 mg/L [13]. However, a recent study has indicated nitrate concentration of shallow ground water in Chaj Doab area vary from as low as 2 mg/L to as high as 450 mg/L [14]. In NWFP, beside other water quality parameters, nitrate content of underground water in some areas has been reported by Khwaja *et al.*, [15] Khan *et al.*, [16],

Bangash [17] and Wasim [18]. In the present investigations, nitrate as well as nitrite contents of drinking water samples from various localities in Peshawar, Mardan, Charsadda and Nowshera districts of NWFP were examined over the past ten years. Details of the investigations carried out and results achieved are described and discussed in this paper.

Results and Discussion

Chemical analyses were carried out for pH, alkalinity, hardness, sulphate, chloride, potassium, sodium, nitrate and nitrite. However, in view of the bulk of the analytical data obtained, for the present report only the results of nitrate and nitrite analyses of water samples from different localities in Peshawar, outskirts of Peshawar, Mardan, Nowshera and Charsadda would be described and discussed.

Nitrate contamination of sub-surface water

Yearwise nitrate and nitrite concentrations of sub-surface water in different areas of NWFP are shown in Table 1 and 2.

The areas studied in Peshawar were city, cantonment, university and Hayatabad, whereas nitrate-concentration over the years was found to be well below the WHO [19] approved limit of 45 mg/L. For city area, except 1987-88 generally the nitrate concentration was found in the range 1.50 - 3.60 mg/L. In the earlier reports, nitrate concentrations of city water samples in 1962 [15] and 1981 [17] were found to be 1.19 mg/L and 9.70 mg/L, respectively. In the cantonment area also higher nitrate concentration (2.5 - 4.5 mg/L) were shown for 1988-89 as well as 1992-93. Water samples from Hayatabad area showed higher nitrate concentration (3.60 - 4.80 mg/L) as compared to city and cantonment areas of Peshawar. Nitrate contamination of sub-surface water appeared to be on the increase in the recent years. In the earlier studies [15,17] it was reported to be in the range 0.30 - 1.10 mg/L, whereas in the present study it was found to be in the range 2.50 - 5.20 mg/L. Except for city area which after 1987 showed a decreasing level of nitrate contamination of sub-surface water, no regular decreasing or increasing patterns of the nitrate contamination were observed in other areas of Peshawar under study.

Table-1: Nitrate and nitrite concentration (ppm) in water samples from Peshawar areas

Year	Source	City Area (NS=15)		Cantonment Area (NS-10)		University Area (NS=13)		Hayatabad Area (NS-10)	
		Nitrate	Nitrite	Nitrate	Nitrite	Nitrate	Nitrite	Nitrate	Nitrite
1986	Tubewell	2.30	N.D.	2.80	N.D.	4.30	N.D.	2.50	N.D.
1987	Tubewell	8.60	N.D.	3.90	N.D.	5.20	N.D.	3.80	N.D.
1988	Tubewell	6.50	N.D.	4.20	N.D.	4.50	N.D.	3.60	N.D.
1989	Tubewell	-	N.D.	5.10	N.D.	3.50	N.D.	2.50	N.D.
1990	Tubewell	3.60	N.D.	3.80	N.D.	2.50	N.D.	3.80	N.D.
1991	Tubewell	3.20	N.D.	3.20	N.D.	4.35	4.70	3.90	N.D.
1992	Tubewell	3.25	3.3	4.20	N.D.	3.80	N.D.	4.20	N.D.
1993	Tubewell	3.20	N.D.	4.50	N.D.	3.20	N.D.	4.50	N.D.
1994	Tubewell	1.85	N.D.	2.50	N.D.	3.80	N.D.	4.80	N.D.
1995	Tubewell	1.50	N.D.	3.80	N.D.	2.80	N.D.	4.60	N.D.

NS = Number of samples
ND = Not detected.

Table-2: Nitrate and nitrite concentration (ppm) in water samples from some District of N.W.F.P.

Year	Source	Mardan (NS=10)		Nowshera (NS-10)		Charsadda (NS=10)		Outskirts of Peshawar (NS-11)	
		Nitrate	Nitrite	Nitrate	Nitrite	Nitrate	Nitrite	Nitrate	Nitrite
1986	Tubewell	4.30	N.D.	1.50	N.D.	1.50	N.D.	1.50	N.D.
1987	Tubewell	4.30	N.D.	2.50	N.D.	1.20	N.D.	1.30	N.D.
1988	Tubewell	4.80	N.D.	5.30	7.50	1.50	N.D.	2.50	N.D.
1989	Tubewell	4.50	8.60	3.20	N.D.	2.20	N.D.	3.80	N.D.
1990	Tubewell	3.50	5.60	3.50	N.D.	1.80	N.D.	4.50	N.D.
1991	Tubewell	2.50	N.D.	3.60	N.D.	1.50	4.70	6.35	N.D.
1992	Tubewell	3.20	0.25	3.80	N.D.	1.90	N.D.	8.30	N.D.
1993	Tubewell	1.60	N.D.	5.80	1.80	2.10	N.D.	8.50	N.D.
1994	Tubewell	1.50	N.D.	5.60	N.D.	3.20	N.D.	8.80	N.D.
1995	Tubewell	2.80	N.D.	1.80	N.D.	1.60	N.D.	9.20	N.D.

NS = Number of samples
ND = Not detected.

Over the years the nitrate contamination of sub-surface water in the outskirts of Peshawar, along Peshawar-Charsadda road appeared to be on the increase and was observed in the range 1.50 - 9.2 mg/L (Table 2). This may be due to enhanced industrialization and agricultural activities in the area. For Charsadda area, the nitrate content in the water samples studied was found to be the lowest (1.20 - 3.20 mg/L) compared to the nitrate concentration levels observed in water samples from Mardan (1.50 - 4.80 mg/L) and Nowshera (1.50 - 5.80 mg/L) areas (Table-2). In an earlier report published in 1962, the nitrate concentration of sub-surface water samples from Mardan and Noshera areas was found to be 1.42 mg/L and 1.77 mg/L, respectively [20]. Water samples from Mardan, Nowshera and Charsadda areas did not show any uniform increasing or decreasing patterns of nitrate concentration levels over the years (Table-2).

Nitrate content of sub-surface water is generally higher than surface water of an area [7] and it was also found to be so in the present investigation. Nitrate content of main Kabul river and its branches at Naguman and Shah Alam has been reported to be 1.09 - 1.78 mg/L, 0.02 - 0.57 mg/L and 0.41 - 1.17 mg/L, respectively [21] which were lower than the nitrate content of sub-surface water samples given in Table 1 and 2.

Nitrate contamination of sub-surface water is though to originate from a number of sources, including extensive use of fertilizers and human/ animal wastes [22-24]. Schmidt has reported high nitrate content with high chloride content of sub-surface water and has attributed it to nitrate contamination of sub-surface water arising mainly from human and animal wastes. However, nitrate contamination has also been considered to be mainly from the use of fertilizers if high nitrate content of sub-surface water was observed with high potassium content [24]. In the present study of sub-surface water, no such co-reatiolship between nitrate content and chloride or potassium content was observed and therefore, the nitrate contamination in the areas studied may be arising from both the agricultural activities as well as human and animal wastes. May be ascertaining the source of nitrate contamination be possible only in areas with high nitrate content (above 45 mg/L) as has been reported by Schmidt [24].

Nitrite contamination of sub-surface water

The presence of traces of nitrite in water is regarded as an indication of water being polluted and probably bacteriologically unsuitable for drinking purposes [7,25]. Water samples from Peshawar cantonment, Hayatabad and Charsadda areas (Table-1 and 2) appeared to be free from nitrite contamination. The presence of nitrite was also not observed in sub-surface water samples from Peshawar University (Table-1) and outskirts of Peshawar (Table-2) except for 1991 (4.70 mg/L) and 1988 (1.30 mg/L), respectively. Between 1987-89, some of the samples from Peshawar city, Mardan and Nowshera areas indicated the presence of high concentration of nitrite which is alarming in view of the earlier report [15] showing absence of nitrite in water samples from these areas. However, since 1993, nitrite presence has not been detected in sub-surface water samples from all the areas under present study.

Experimental

Sampling

Plastic bottles (1.5 litre capacity) for sampling were carefully cleaned with detergent, washed several times with laboratory tap, water, rinsed with HCl, again with tap water and finally with distilled water. All necessary precautions [7,26] were observed while filling up the sample bottles with tubewell water, their transport and storage. Tubewell selected for sampling at Peshawar, Charsadda, Mardan and Nowshera were far-apart and were well-used by the communities living around the areas.

Nitrate analysis

Nitrate content was determined spectrophotometrically by phenoldisulfonic acid method. The intensity of the yellow colour formed due to alkaline salt of 6-nitro-1,2,4-phenol disulfonic acid was measured at 420 nm on spectrophotometer model LS-7, Erma, Japan. For comparison standard solutions were prepared using anhydrous A.R. potassium nitrate.

Nitrite analysis

Diazotization method was used for the determination of nitrite content of water samples under examination. A reddish purple azo dye is

produced in acidic solution by the coupling of diazotized sulfanilic acid with 1-naphthylamine hydrochloride. The intensity of the colour was measured at 520 nm with the same spectrophotometer employed in nitrate determinations. Standard nitrite solutions were prepared using anhydrous A.R. sodium nitrite.

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