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Nitrate, Fecal Coliform and Pesticides in Shallow Groundwater of Raiwand, Lahore Shahzad Afzal

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NITRATE, FECAL COLIFORM AND PESTICIDES IN SHALLOW GROUNDWATER OF RAIWAND, LAHORE, PAKISTAN

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ABSTRACT

Nitrate, fecal coliform(FC) and pesticide contamination of a shallow groundwater of Raiwand are concerned because of potential adverse effects on human health. It is frequently assumed that the gradual increase in nitrogen fertilizers, pesticides and dumping of municipal solid waste over the last 30 years is the primary cause of high concentration of these pollutants in groundwater of Raiwand, Lahore, Pakistan. Groundwater samples collected during summer 1995 from 42 sites and were analyzed for major cations, anions, NO_3, fecal coliform and 2 pesticides.

Fifty-six percent of the water sample surveyed were not fit for irrigation due to high RSC (Residual sodium carbonate), SAR (Sodium adsorption ratio) and TDS (Total dissolved substances). Fifty-three percent of the samples have NO_3 concentrations above 45 mg/L and sixty seven percent of the samples have fecal coliform densities >3/100 mL, which are not fit for drinking purpose according to WHO guide lines. The most commonly detected residues were parathion and malathion for pesticides and their mean concentrations were 0.63 and 0.37 micro gm/L, which were well below the toxic limits.

INTRODUCTION

For great many years it has been recognized that soil has substantial capacity for decomposing waste products and renovating polluted groundwater. Less well appreciated has been that nature's recycling mechanisms are in a delicate state of balance and, moreover, have very finite limit. For many years, environmentalists protested in vain against the increasing abuse of the natural geohydrologic regime as a limitless resource for waste disposal and water reclamation. Finally the result of this abuse started to show in the form of widespread degradation of groundwater quality Raiwand, Lahore, Pakistan. Strict accountability is now being demanded of those who generate and handle hazardous waste.

Several studies have shown that a significant amount of water alongwith agricultural chemical can flow through macro-pores into and below the root zone in few minutes after water is applied to soil surface (Quisenberry and Phillips, 1978; Thomas and Philips, 1979; Priebe and Blackmer, 1989).Moreover, soil structure, soil cover, and rainfall intensity all affect the actual amount of water that moves through macro-pores.

Concern over existing and potential NO_3 contamination of ground and surface waters has dramatically increased over the past few years. Nitrogen in its several forms in drinking water can pose a health hazard. For example, nitrate (NO_3) can cause methemoglobinemia ("blue baby" disease) (Vigil

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and others, 1965), and ingestion of water containing high concentrations of nitrate (NO_3^-) or nitrite (NO_2^-) may cause chronic toxicity and possible development of cancer from nitrosoamines (U.S. Environmental Protection Agency, 1976; Safe Drinking Water Committee, 1977).

Diseases causing organisms in drinking water pose a serious threat to human health. Many of these originate from water pollution with human excrement. Fecal coliform bacteria concentration in a water body is therefore a useful criterion for determining water quality for drinking (Chapman 1992).

Pesticides have played a major role in the world's struggle against food shortages and vector-borne diseases. Our society and economy would be radically different without them. However, pesticides present a continuing problem of contamination. With long-term use, pesticides are more likely to be present in low but consistent levels (Cooper, 1991) and may pose unknown, sublethel problems.

Widely dispersed industrial and agricultural developments have made the surficial and confined aquifers important sources of water supplies. At present there are a few confined aquifers present in the area. In some wells generally being screened deep below 300 feet (Seepcol Power Generation) to ensure good supply and avoid water-quality problems, but at that depth even the water is bad in odor and yellow in color, Now at present Seepcol Power Generation are providing drinking water from Lahore to their workers. There are many such problems present in the area due to scarcity of good quality drinking water. The objective of this study was to determine the effect of NO_3, FC and pesticides from municipal waste, industrial waste and agricultural practices in the area on shallow groundwater.

INVESTIGATED AREA

The study area comprises of 40 Km^2 of agricultural land and industrial area adjoining with Lahore lies in 44 I/7 and 44 I/3 index. Depths to the water table generally are shallow, ranging from 2.6 to 5 meter in many sites, but depths are 10 meter or more in some well-drained areas. The depth of groundwater at a site also varies seasonally (1-2m), mainly because of seasonal changes in evapotranspiration.

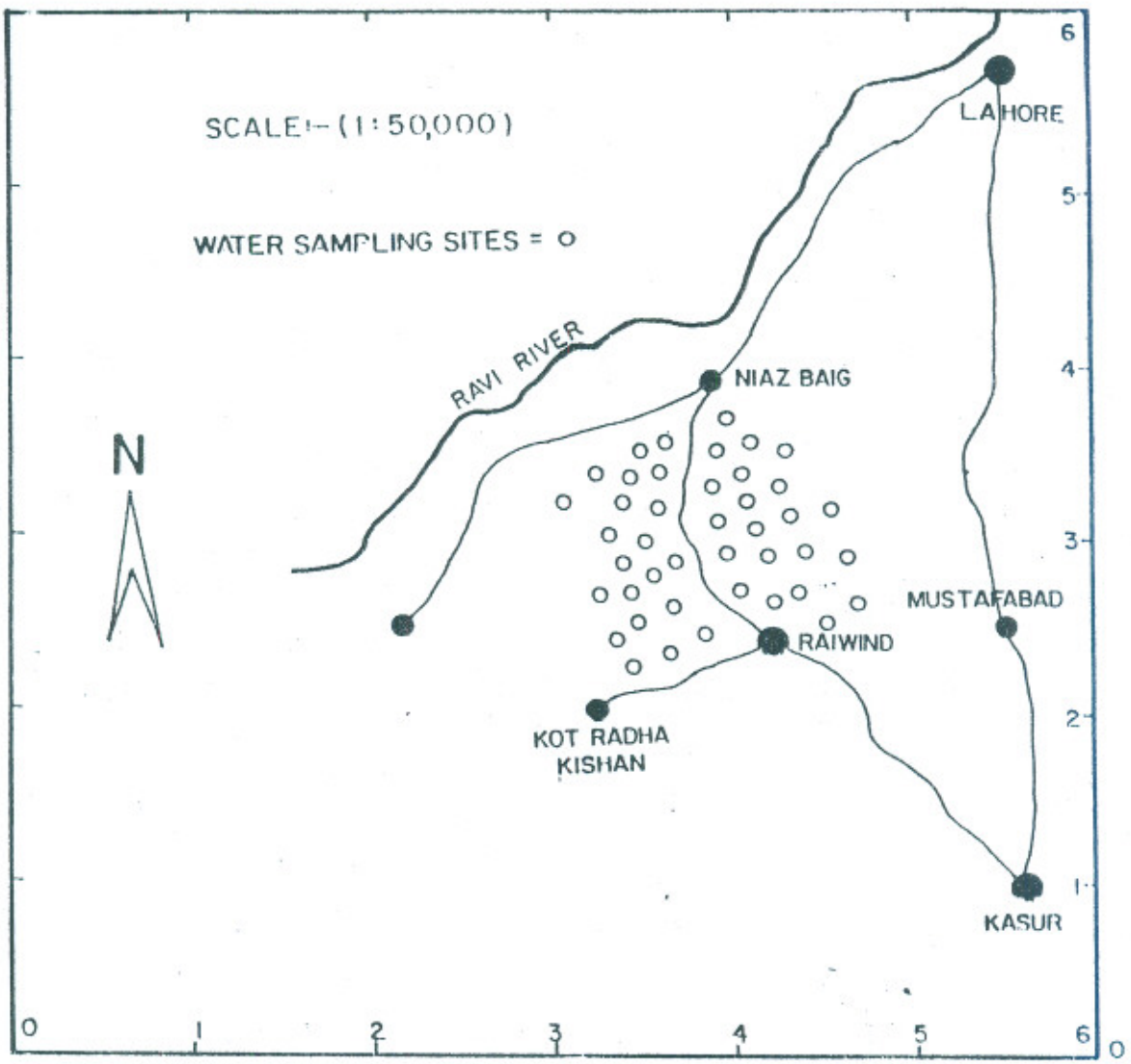
The principal seed crops growing in Raiwand, Lahore includes Wheat (Tritcum aestivum L.,) Maize (Zea mays L.), Rice (Oryza sativa L.) and barley (Hordeum vulgare L.). Annual precipitation of last five years from 1991 to 1995 varied greatly and ranged from 374 to 826 mm. The means annual irrigation was 324 mm/year and was applied 7 or 8 irrigation events. However, the annual amount of irrigation ranged from 220 mm to 460 mm, depending on the climate conditions. The total means annual water input (irrigation plus precipitation) was 916.2 mm (Shahzad et al., 1995).

Beneath the surficial aquifer is a series of unconfined and confined aquifers, most of which are in geologic contact with the surficial aquifer. This area of contact (subcrop zone) can be a direct pathway for contaminants to move from the surficial aquifer into the unconfined and confined aquifers.

METHODOLOGY

Fourty two water samples were collected from different sites in July and August, 1995 (Fig 1). At each sampling site the well's characteristics (type of construction, casing, depth, age and use) were

FIG.1. LOCATION MAP OF WATER SAMPLING SITES



recorded along with the well's location relative to the land surface and to potential sources of contamination. Information on the use of agricultural chemicals in the surrounding area was also recorded for pesticides.

Samples for major cations, anions and NO_3 determinations were collected in acid-cleaned polyethylene bottles and reached the laboratory where they immediately were filtered through 0.45 micron meter filters and refrigerated. Standard analytical procedures were adopted (EMSL., 1983, APHA..,1985) The pH and EC of the water samples were measured in the field. Waters collected in polyethylene bottles were analyzed for Total P, NO_3 and SO_4 using a Spectrophotometer (Hitachi U-1100). Calcium and Magnesium were determined by atomic absorption spectrometry using Perkin Elmer Model 2280. Sodium and potassium were determined by flame photometer (Jeanway). The methyl orange method was used for alkalinity determinations and chloride by titration against silver nitrate.

Bacteria samples were collected according to the American Public Health Association (1975) procedure and stored on ice until returned to the laboratory. Bacterial examination began within 24 hours of sampling. The membrane filter technique was utilized for fecal coliform (FC) tests (Am. Public Health Asoc., 1975) and aseptic techniques were strictly followed. M-FC media was used for FC determinations, respectively. Incubation temperatures for the FC cultures were maintained at 44.5 + 0.2°C.in a water bath

Some insecticides in current use are more toxic than banned organochlorines. Parathion and malathion have approximately the same acute toxicity (LC_{50}) as DDT (Sanders and Cope, 1966). Parathion and malathione are in use for last15 years in this area Pesticides samples were obtained in 4-liter glass jugs. These samples were extracted using the XAD-2 resin extraction procedure of Junk et al. (1976) and analyzed by electron capture gas chromatograph with different polarity columns. Detection limits were 0.04 ug/L for parathion (O,O-diethyl O-4-nitrophenyl phosphorothioate) and malathion (O, O-diethyl phosphorodithoate of diethyl mercaptosuccinate).

Each mean of the sampling well represents the average of 3 to 5 observations for the unconfined and confined groundwater, respectively. All data is presented as the range, mean and standard deviation.

RESULTS AND DISCUSSION

Chemical composition data for the water samples are given in the Table 1-2 (Where range, mean and standard deviations are shown). 56 % of the water sample surveyed are not fit for irrigation due to high RSC, SAR and TDS (Table.1) as described by (Richard, 1954), 67 % of the water samples are not fit for drinking (Table 2), as described by (APHA.,1985; WHO, 1992).

Groundwater NO_3 concentrations at the 42 sampling sites ranged from <7.4 to 167 mg/L. At 53 % of the sites NO_3 levels exceeded the 45 mg/L MCL (maximum contamination level). Although acute toxicity generally has been documented at concentrations greater than 100 mg/L NO_3, the MCL has been set at 45 mg/L. The presence of such wide range of NO_3 concentrations and the high degree of heterogeneity over very short distances is indicative of point-source contamination. In the study area, the major source of nitrate is the dissolution of manure in feedlots, wastes of poultry, nitrogen fertilizers and municipal waste of Lahore city are the sources of NO_3 in the area.

The common usage of parathion and malathion and their relative high aqueous solubilities suggest that they may be candidates for vertical transport to the aquifer. Parathion was found in detectable quantities in 7 samples and malathion was found 4 samples, analyzed for pesticides. The mean concentration of parathion and malathion were 0.63 and 0.37 micro gm, respectively. In our case the concentrations of these pesticides were well below potentially hazardous levels of 49.0 and 53.0 micro gm/L for parathion and malathion (Williams et al., 1988).

Fecal coliform bacteria are ranged from 0 to 900 FC/100 mL against the acceptable concentration of 3FC/mL Sixty-nine percentage of the samples have fecal coliform densities > 3FC/100 mL .Usually an undisturbed aquifer will yield groundwater having low indigenous coliform bacteria populations. Thus, the presence of microorganisms such as fecal coliform bacteria, , is indicative of groundwater contaminated by inadequately filtered recharge and can be a useful parameter in evaluating well contamination.

CONCLUSION

There is an estimated 4 billion m^3 (1.5 trillion galons) of contaminants that go into the ground each year that threaten groundwater supply (Liston, 1989). Once these contaminants reach a groundwater, they can persist for many years causing major health concerns for those using groundwater as their drinking water source.

Application of water to the soil with high RSC for extended period of time sodicate the soils. On these experimental findings, groundwater of the area should be used, after mixing with canal water on the basis of RSC, SAR and TDS parameters.

The NO_3 and FC (fecal coliform) concentrations found in groundwater probably represent a human health hazard because (I) this shallow groundwater is consumed by the local people (ii) concentrations of NO_3 and fecal coliform are above the health advisory levels (45 mg/L NO_3, 3 FC/100 mL) set by WHO.

The pesticide concentrations found in groundwater probably do not represent a human health hazard because the concentrations were usually below the health advisory levels 49 and 53.0 micro gm/L for parathion and malathion (Williams et al., 1988).

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Table. 1. Chemical analyses of selected groundwaters of Raiwand for irrigation purpose.

Parameters	TDS mg/L	pH	Ca mol m^{-3}	Mg mol m^{-3}	Na mol m^{-3}	K mol m^{-3}	Alkalinity mol m^{-3}	Cl mol m^{-3}	SO_4 mol m^{-3}	Res Na_2
Range	1544-2744	7.3-8.4	1.8-5.2	2-6.25	17.5-32.4	0.2-0.9	8.5-15.2	4.5-6.3	11-18	1.3
Mean	2313.8	7.9	3.7	5.6	25	0.67	10.9	5.42	13.9	1
Standard deviation	427	0.3	1.62	3.04	5.8	0.5	3.1	2.9	3.4	0

Table. 2. Chemical analyses of selected groundwaters of Raiwand for drinking purpose

Parameter		Measured values	Permissible Range	Reference
Calcium	Range	36-104	100 mg/L	Anon 1976
	x	74.6		
	STD	32.4		
Magnesium	Range	24-76	150 mg/L	Chapman 1992 (WHO)
	x	68		
	STD	37		
Sodium	Range	402-764	200 mg/L	Chapman 1992 (WHO)
	x	574		
	STD	132.6		
Potassium	Range	7.9-34	mg/L	
	x	26		
	STD	18.3		
Alkalinity	Range	518-926	20-400 mg/L	NTAC, 1968; NAS 1974
	x	664		
	STD	184.2		
Chloride	Range	159-224	250 mg/L	Sawyer 1960
	x	192.4		
	STD	102		
Sulfate	Range	528-874	1000 mg/L	Trevedi et al.1992 (India)
	x	668		
	STD	163		
Nitrate	Range	8.7-168	45 mg/L	Chapman,1992 (WHO)
	x	36.8		
	STD	13.2		
pH		7.3-8.4	6.5-9.2	Chapman,1992 (WHO)
	x	7.9		
	STD	0.3		
TDS		1544-2774	1000 mg/L	Chapman, 1992 (WHO)
	x	2313.8		
	STD	427		
Fecal		0-750	3 FC/100 ml	Anon 1971 (WHO)

Coliform Range	x STD	374 270		
Parathion	Range x STD	0.21-0.46 0.63 0.17	49 micro g/L	Goodrich , 1991
Malathion	Range x STD	0.1-0.54 0.37 0.14	50 micro g/L	Goodrich , 1991

x= Mean

1. STD= Standard deviation