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AN INVISIBLE THREAT TO DEEP GROUNDWATER, CONTAMINANTS ASSESSMENT IN SHALLOW AQUIFERS AND MEASURES TO PREVENT DEEP AQUIFERS CONTAMINATION IN CENTRAL PUNJAB, PAKISTAN

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By:

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Abstract

Water is the basic need for human and domestic consumption. In the area of research central Punjab, most of the population in cities and towns are using groundwater for drinking, domestic and industrial requirements. In addition, conjunctive use of groundwater with canal water for irrigation is frequent. Most of the population living in villages and towns of the central Punjab generally strike shallow groundwater up to 100 feet deep as the majority of the population living beyond the poverty line and can't afford to install deep tube well to access safe drinking water to meet their day by day water requirement. As we know, almost every home in villages has a soakage pit and an open dike toward a pond to dispose of human feces and waste water which cause contamination to shallow aquifers. By using the same water extracted through hand pumps and injector wells, without treatment, water borne diseases are frequent.

The aquifers underlying central Punjab in Rechna and Bari Doabs are being recharged by means of Groundwater inflow and surface water infiltrations from rainfall, rivers, and canals and partially through unlined sewerage ponds and wastage drains. Later two sources are major contamination hazards to shallow groundwater aquifers. Due to the unconfined nature of the underlying aquifer, the deep fresh water aquifers have permanent threat of contamination in near future which can't be neglected. The general practice usually adopted to overcome the contamination issues is to propose treatment plants but the root cause of contamination source is barely addressed that is to prevent mechanism to reduce the risk of contamination sources on surface. This paper focuses on the increasing concentration of arsenic and bacterial concentrations in shallow aquifers in central Punjab area and to realize the threats to deep water contaminations. The chemical analysis data of water samples collected from different cities and towns in central Punjab projects is compiled and analysed to determine the nature and extent of contamination and recommendations to fix the problem before reaching the contamination to deep aquifers.

Keywords: Shallow water contamination, Arsenic, Biological, Central Punjab, Threats to deep aquifers

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INTRODUCTION

The study area constitutes the five districts of central Punjab Pakistan (Lahore, Sheikhupura, Nankana, Faisalabad and Okara). The study area falls in Rachna and Bari doab's aquifers. The major contaminations reported in study area are increasing Arsenic concentrations and biological contaminations. The unlined and unplanned sewage systems in the villages and waste drains in cities in the study area resulted in deterioration of underlying shallow aquifers quality. In response to this problem, treatment plants are proposed while the surface contamination hazards barely addressed. As a result contamination process continues to pollute the aquifers. In order to assess the threats of these shallow water contaminants to deep fresh water aquifers, the geometry of aquifers underlying the study area is discussed in the following paragraphs.

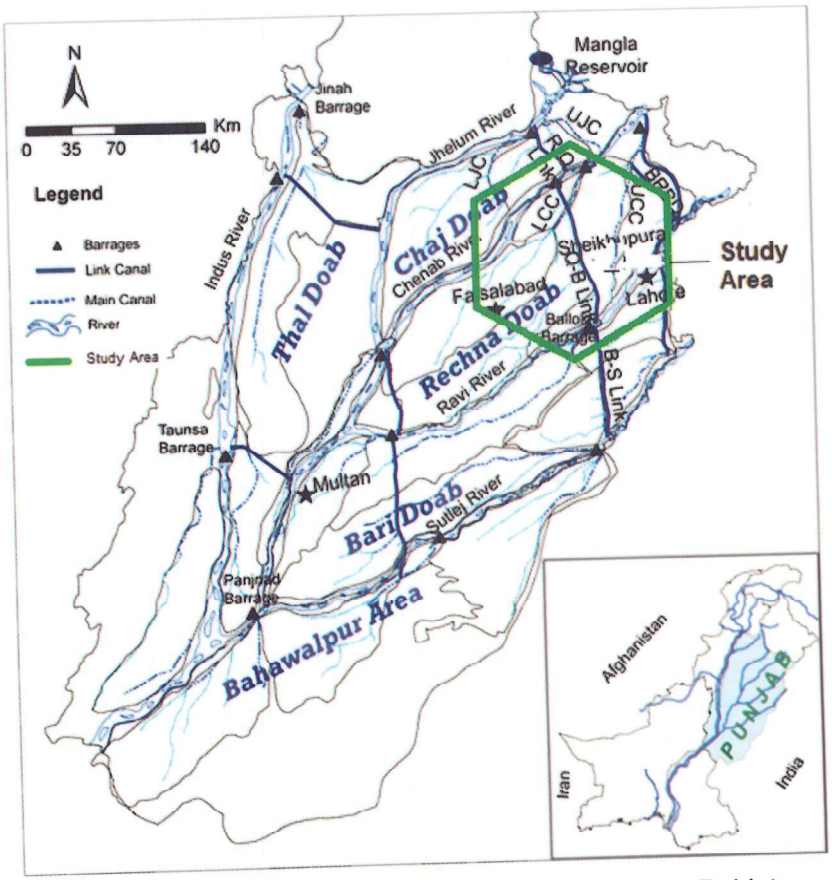


Figure-1: Study area boundary of Central Punjab Pakistan

The central Punjab area is part of Rachna and Bari Doabs. The underlying aquifers are considered as single unconfined aquifer up to the average vertical distribution of 400 meters in the study area. The major lithological unit of aquifer is sand associated with variable thickness of clay layers. These clay patches deposited variably in study area act as a natural filter to prevent the contamination and maintain the quality of deeper aquifer. A comprehensive aquifer study carried out in 1960s with plenty of exploratory boreholes

as shown in the Figure-2 below depicts the nature and orientation of the under lying unconfined aquifers. The clay deposits vary from few centimeters to several meters in the study area. The hydraulic gradient in the study area and heterogeneous nature of clay patches, it can be revealed that any contaminant may transport into the deeper aquifers. The contamination in any shallow water may be able to contaminate the deeper fresh aquifer in future. The solution to address the contamination hazards at surface is unfortunately ignored in the area. The following figure help to assess the aquifer unconfined nature and deposition of clay patches.

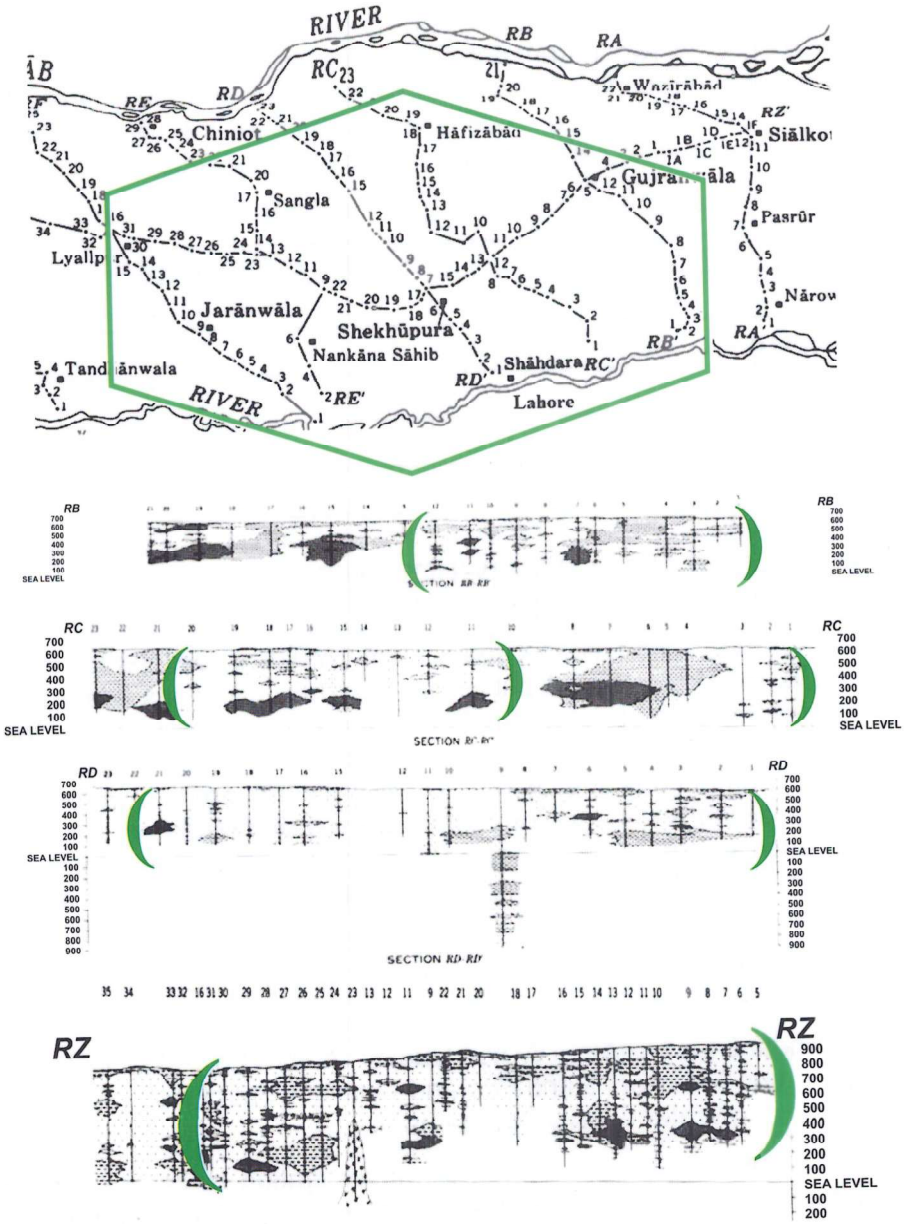


Figure-2: Lithology of study area

Another source of contamination adopting frequently by number of stakeholders is aquifer artificial recharge techniques. While adopting and proposing such techniques, the quality of injected water is not taken into consideration. As a result, surface run-off generated water when injected directly into the aquifer without treatment, may cause serious threats to the quality of the aquifer.

METHODS

Water samples collected from shallow water wells installed less than 100 feet depth below ground were sorted from samples collected during the project investigation phases of different projects conducted in the study area. For the purpose of shallow water contamination only two parameters (Arsenic and Biological) were analyzed as both parameters concentrations are commonly reported in the study area. Total eighty eight (88) Nos. of samples sorted from different cities of the central Punjab for the analysis of both contamination parameters i.e. Biological and Arsenic Contamination.

District-wise number of samples analysed is given in the following table:-

Name of City	Nos. of Analyzed Samples
Lahore	11
Sheikhupura	25
Nankana	30
Faisalabad	15
Okara	7

WORLD HEALTH ORGANIZATION (WHO) GUIDELINES AND PAKISTAN STANDARDS FOR DRINKING WATER

The primary aim of the World Health Organization (WHO) guidelines for drinking water quality (GDWQ) is the protection of public health. The Guidelines are intended to be used as a basis for the development of national standards that will ensure the safety of drinking water supplies through the process of elimination, or reduction to a bare minimum concentration of constituents in drinking water that are known to be hazardous to health. The guideline values recommended are not mandatory limits. They are intended to be used in the development of risk management strategies which may include national or regional standards in the context of local or national environmental, social, economic and cultural conditions.

In Pakistan, the WHO provisional guidelines of 0.01 mg/L have been adopted as the standard permissible for Arsenic.

The National Standard for Drinking Water Quality (NSDWQ) Pakistan Environmental Protection Agency and Pakistan Standards and Quality Control Authority (PSQCA) are responsible for Drinking Water Quality Standards.

Wongsasuluk *et al.* has reported a systematic investigation of carcinogenic and non-carcinogenic effects of heavy metals on an agricultural area of Thailand. Human health risk assessment has been made for all heavy metals including Arsenic. Rapant and

Krcmova´ reported that the cancer risk caused by Arsenic in groundwater reached as high as 10^{-4}, or more than 100 people in a million in Slovakia.

DISCUSSION OF RESULTS

Arsenic contamination of groundwater of five districts of central Punjab is listed in Table-1 below: The highest number of quality affected in terms of exceeding percentage of collected shallow water samples in certain district is recorded in Faisalabad and Lahore (87% and 82% respectively). Sheikhupura District's arsenic exceeding limit percentage found in 72% samples, Nankana District's arsenic exceeding limit percentage found in 53% samples and Okara District's arsenic exceeding limit percentage found in 29% samples.

Biological contamination of groundwater of central Punjab districts is listed in Table-2. The highest number of quality affected habitations is recorded in Sheikhupura district in which 80% samples exceed the limits mentioned in standards, while in Lahore 55% samples, in Nankana 63% samples, in Faisalabad 53% samples and in Okara 57% samples exceed the limits.

In the area of research, typical pattern has been observed in the distribution of heavy metals in groundwater of Punjab. The highest Arsenic contamination is recorded in Lahore along left bank of Ravi River. The sources of Arsenic are considered to be geogenic, but increasing percentage is reported during periodic sampling in this area.

Table-1: Arsenic Content in Groundwater of Central Punjab (Acceptable limit=0.01mg/l=10ppb).

Name of City	Arsenic Concentration < 10 µg/l	Arsenic Concentration 10-50 µg/l	Arsenic Concentration >50 µg/l	Exceed %age
Lahore	2	5	4	82
Sheikhupura	7	12	6	72
Nankana	11	15	1	53
Faisalabad	2	7	6	87
Okara	5	2	0	29

Table-2: Biological Contamination in Central Punjab No. Colony Farming Units (Number of bacteria or fungal cells Colony Farming Unit /100 ml of sample)

Name of City	Biological Concentration CFU (Within limits)	Biological Concentration CFU (above limits)	Biological Concentration CFU (Unlimited)	Exceed %age
Lahore	5	6	0	55
Sheikhupura	5	13	7	80
Nankana	11	5	14	63
Faisalabad	7	2	6	53
Okara	3	1	3	57

CONCLUSIONS AND RECOMMENDATIONS

1. Groundwater contamination in shallow water for studied parameters in central Punjab is alarming. Considering the contamination percentages found in shallow water is an alarming threat to the deep water aquifers in future.
2. Un-planned and scattered sewage ponds in villages and sewage drains in cities are major sources of contamination to Groundwater and the problem is barely addressed. Considering the unconfined nature of aquifer, the contamination threat to deep aquifer cannot be ruled out.
3. Prior to the contamination reach the deeper aquifer; certain measures should be adopted at once to control the contamination sources. Waste water should be poured in to the channels and ponds after treatment. This norm should be declared mandatory in Master planning of new societies, towns and industries.
4. The rain water harvesting through groundwater recharge technique shall only be permitted for water collected on roof tops, abundant rivers and in selected recharge areas. Surface runoff prior to injection into ground through recharge wells shall only be allowed after making sure that the provision of surface contamination in the design of recharge well is provided.
5. Regional level awareness is recommended to highlight the threat of contamination to deep aquifers which the hidden source of water for future generations.

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