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Research Article

Water Pollution from Agriculture and Industry

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Abstract

Continued water quality impairment has introduced serious environmental concerns for health, stream life, agriculture, and industry. In general, water pollution is a resultant of agricultural and industrial activities. We handpicked 150 samples of drinkable water from various parts of the Faisalabad City. The findings revealed that locations fed by industrial waste matter had higher nitrate level, whereas places with superior drainage had lower nitrate content. Almost all the factors in general produced major effects on the leaching of fertilizer (NO_3-N) into the soil outline. The current research found that nitrogenous fertilizer in the form of NO_3-N was leached up to 150 cm into the soil. In Pakistan, the water table was within 150 cm of the ground surface on 30 percent of the 41 million acres examined. The municipal and industrial wastes of Faisalabad cannot be separated, as industries are situated in residential areas. The mixture is discharged into open land or into drains. None of the samples contained Zn in the tolerance limit (TL refers to the concentration higher than maximum permissible limit). MPL decrease with an increase in distance of the source from the sullage carrier. Fe, Cu and Mn, the results indicate that the sullage carrier has contaminated the ground water up to 300 meters and no water sample was found within TL within 300 meters distance. The results indicate that Fe, Cu, and Mn concentration in ground water has reached to problematic level along unlined section of the sullage carrier. Thus, in this zone a severe Fe, Cu and Mn toxicity has been identified. Pb however, the situation was somewhat different because none of the samples was found within TL after 50 meters distance of source from such sullage carrier. The result of Fe indicates problem in some water samples collected along lined section of sullage carrier. The same situation prevailed for Cu and Mn. Both the metals have contaminated the ground water up to 150 meters. The results of Pb were similar as in case of unlined section of the sullage carrier but it has some problem up to 25 meters. This paper describes some aspects of surface and subsurface water pollution, in addition to best management practices and remedial measures required for minimization environmental hazards.

Keywords: *Agriculture, Environment, Industry, Nitrogenous fertilizer, Contamination, Water quality*

1. Introduction

Agriculture-related water pollution has immediate negative health consequences, such as the well-known blue-baby syndrome, in which excessive nitrate levels in water cause methemoglobinemia – a potentially fatal condition – in infants (Mateo-Sagasta *et al.,* 2017). The principal pollutants poisoning water bodies, particularly during flood events, are human and industrial (including agricultural) wastes. Heavy metals and pesticide-related carcinogens are dumped into water bodies by various sectors, resulting in pollution, which puts rural communities in particular at danger (Ahmed *et al.,* 2016).

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Groundwater pollution has gotten so severe in certain sections of the country that extensive groundwater resources may be harmed unless immediate action is taken (Daud *et al.,* 2017). Since the inception of universe, man has been constantly tampering with the natural ecosystem and causing undesirable changes. But recent population explosion and resulting overuse of the sources has generated environmental imbalance/pollution that presents a potential danger to humanity (Okyere, 2011). There are many and varied environmental problem. All these may, in broader sense, be classified into water, air and land pollution. Water pollution is injury of water excellence by farming, household, or industrial wastes to an extent that has an unpleasant consequence upon any positive usage of hose (Charbaji *et al.,* 2021). Generally, water pollution stems from either agriculture or industry (Laitos *et al.,* 2013). As a result of human activity, the quality of groundwater in some places of Pakistan is deteriorating. Because the soil and rocks through which groundwater runs screen out most bacteria, groundwater is less susceptible to bacterial pollution than surface water. Bacteria, on the other hand, made their way into ground water on occasion, sometimes in dangerously high numbers. However, the absence of microorganisms does not imply that the water is safe to drink. Groundwater contains a variety of invisible dissolved minerals and organic components in varying amounts. Most are safe or even useful; others, though rare, can be hazardous, and a few can be severely toxic (Talabi *et al.,* 2019). Most of the research was done to see how nitrates leached under different quantities of tillage, different types of implements, different fertilizer doses, different irrigation depths, and different sample times following fertilizer application. The experiments incorporated nitrogenous fertilizers. The main objectives of these studies were to establish the extent (horizontal) of ground water contamination by heavy metals along the sides of a sullage carrier and to ascertain the rate of heavy metal deposition in the sullage carrier. To determine the ground water contamination level, water samples were collected from existing hand pumps, donkey pumps, and open wells located within the range of 3 m to 426 m along the sides of the sullage carrier. Sixty-one water samples, 45 from hand pumps, 14 from donkey pumps, and 2 from open wells, were collected.

This paper highlights some of the recent studies conducted by the authors for contribution of agricultural and industrial sectors in pollution of both surface and subsurface waters.

2 Agricultural Pollution of Water

Intensive agricultural practices are continuously deteriorating the water on which depends the very existence of life on this planet. Between all risks associated with farming, agrochemicals have risen to the top of the list, posing a serious threat to the environment (Production *et al.,* 2014). It is being forecast that the continuous and surplus use of chemicals will leave surface and subsurface irrigate reservoirs unfit for supporting life (Baldock *et al.,* 2000). The agro-chemicals including biocides and fertilizers are poisonous intentionally distributed to make the most of their noxious characteristics. Become water pollutants when reach higher levels (London et al, 2014). Continuous use over the last many decades, these toxic chemicals are found in rivers, wells, lakes, oceans, in the air and soil, fishes, birds, worms, eggs, and, in several cases, mom's milk, as well as perhaps unborn kid tissues (UNEP 2008).

DDT (dichloro diphenyl trichloroethylene) is possibly the most notorious element in this regard. It has been employed to kill both health and rural vermin, saving millions of lives and preventing malnutrition in others (Link, 2006). But an indiscriminate application of the chemical has resulted in global environmental contamination and the extinction of non-target species (Guide *et al.,* 2009). DDT and its crash compounds are found in almost every country on the planet. DDT's poisonous effects have spread from the areas where it was used to far-flung locations. DDT residues have also been found in the bodies of Alaskan Eskimos (The permanent people's tribunal session on agrochemical transnational corporations 2011). DDT is highly adsorbent to soils, which then wash into rivers and seas because of soil erosion. Because of the high volume of sediments discharged into them, water bodies such as lakes, bays, and reservoirs all tend to become DDT traps (Aqeel *et al.,* 2014). DDT wreaks havoc on the nervous and reproductive systems of humans. DDT can affect phytoplankton by preventing it from converting sunlight into energy. However, DDT use is decreasing, and the hazard it poses is diminishing (Tillett, 2005). There is no need to contribute to the already high levels of worldwide water contamination caused using biocides (English, 2021).

2.1 Fertilizers Pollution

Usage of agrochemicals has been identified as a probable cause of environmental contamination, particularly with reference to water excellence. The one that is harmful is nitrate-nitrogen (NO_3-N) pollution at present getting substantial concentration (Barakat, 2020). About 76 percent of the world's population lives in deprived countries; they apply more nitrogen fertilizer than developed countries. Fertilizers are used more often in areas where irrigation is handy and soil and climatic conditions are favorable to agricultural plant growth (Anas *et al.,* 2020). A definite part of the use of agricultural pesticides, which can flow directly from the fields into streams and subsurface sources, causes NO_3-N contamination. The degree of industrial NO_3-N both for upper and underground freshwater varies not fully recognized (Moloantoa *et al.,* 2022). However, circumstantial facts show that water quality worsening is linked with the amplified nitrogen fertilizers use. Groundwater pollution is a significant problem in Pakistan, where wells provide 70% of the country's drinkable water (Khwaja *et al.,* 2018). Pollution of drinking water supplies is a common occurrence (Singh *et al.,* 2021). More research was done to see how nitrates leached under different quantities of tillage, different types of implements, different fertilizer doses, different irrigation depths, and different sample times following fertilizer application. The experiments incorporated nitrogenous fertilizers. Almost all the factors in general produced major effects on the leaching of fertilizer (NO_3-N) into the soil outline.

First study was conducted to watch the leaching and management of nitrates into soil layers after using various tillage implements. The observations are recorded in Table 1 during experiments in a wheat field.

Table 1. Contents of nitrate-nitrogen in several tillage treatments (After first irrigation

Tillage treatment	Depths(cm)				
	0-30	30-60	60-90 Ppm	90-120	120-150
a. Narrow tine cultivator	8.33	5.40	2.53	1.46	0.67
b. Sweep cultivator	9.73	7.60	2.40	1.60	0.00
c. Disk harrow	5.06	4.46	3.00	1.34	0.60
d. M.B. plough	4.86	2.86	1.54	1.06	0.34
e. Chisel plough	6.13	4.40	2.00	0.53	0.43

Sweep-tilled plots outperformed thin tine farming in terms of preserving NO_3-N stuffing in the 0-60 cm soil layer. Sweep-tilled regions can clearly be considered favorable for maintaining NO_3-N in the topsoil layer (0-60 cm), which is the plant's origin bed. The increased nitrate absorption after the first irrigation strongly suggests that leaching efforts can be visible up to 150 cm into the soil with a standard amount of fertilizer and standard irrigation. If this tendency continues in our agricultural areas every year, the day will come when the groundwater pool will be severely polluted. Sadly, this would be a long-term process, and swallowing the contaminated water can pose serious health risks. As can be seen, agricultural chemicals such as fertilizers, herbicides, and insecticides have been used at an alarmingly high rate in recent years (Chowdhury *et al.,* 2009). Chemical-based agriculture is carried out with complete disregard for the consequences for animal and human life (Goldvale *et al.,* 2017). There are two significant drawbacks of fertilizer leaching. To begin with, leaching results in fertilizer loss. Second, the leached substance may contaminate subsurface water, which is often utilized for drinking without being treated. Unfortunately, the extent of agricultural NO_3-N contribution to waterbodies has yet to be determined.

Water is a necessary component of human survival. Unfortunately, while Pakistan has ample surface and groundwater resources, fast population expansion, urbanization, and unsustainable water use patterns have put enormous strain on the country's water resources, both in terms of quality and quantity (WWF, 2007). Increased waterborne infections and other health effects have come from deterioration in water quality and contamination of lakes, rivers, and groundwater aquifers. Pakistan's per capita water availability has fallen from 5,000 cubic meters per year to 4,000 cubic meters per year. In 1951, the population grew from 1,100 to 1,200 (Lytton *et al.,* 2021). Most Pakistanis get their drinking water from this source is a type of groundwater. In Punjab, almost 80% of the groundwater is fresh, but in Sindh, less than 5% is. Fresh groundwater makes up 30% of the total. Increased abstraction has resulted in wells presently being drilled in the NWFP. Much of Baluchistan's groundwater is saline, and it reaches into saline strata (Nafees *et al.,* 2017). Fertilizer contamination poses a direct threat to a large portion of our subterranean water reservoir. Pakistan currently utilizes 56 kg ha^{-1} of fertilizer on average, compared to 779 kg ha^{-1} in Holland. If a result, as fertilizer usage increases, the situation may worsen (Yara Fertilizer, 2018). It is necessary to take steps to reduce the long-term contamination of underground water. Regrettably, most of our anti-pollution measures are focused on cities or industries, and rural division has been completely abandoned (Smith *et al.,* 2016). Drainage, excavation, watering, intercropping, and fertilizing methods all need to be directed to reduce fertilizer's hazard to groundwater contamination (Moore, 2016).

The data, obtained from another study on NO_3-N leaching, were statistically analyzed and results are discussed here. The study included two levels of urea (N_1=125kg/ha & N_2 = 188 kg/ ha) and similarly two levels of surface, irrigation (I_1 = 7.5 cm, I_2 = 15 cm). Tables 2&3 represent the mean NO_3-N values in different soil layers following urea application and watering.

The results revealed that the level of irrigation, fertilizer dose, and sampling depth all significantly increased NO_3-N content in the soil profile. In the case of light irrigation (I_1), greater NO_3-N concentrations were found in the first 30 cm of soil depth. For heavy irrigation (I_2), lower nitrate concentrations were reported in the first 30 cm of depth, and nitrate concentrations increased with depth, peaking at 90-120 cm.

A comparison of NO_3-N levels before and after irrigation (Tables 2 and 3) shows that nitrates were leached up to 150 cm depth after irrigation and urea application. The declining trend in nitrates is expected to continue in irrigations. Negatively charged nitrate ions are just not absorbed in colloidal particles with identical charges, thus they continue to flow downward along irrigation water.

Table 2. Mean values of residual NO_3-N concentration (ppm). (Before irrigation)

Treatment		Soil Depth (cm)				
		0-30	30-60	60-90	90-120	120-150
N_1	I_1	5.0	6.7	3.6	2.9	2.3
	I_2	4.6	6.0	4.0	3.7	1.9
	I_1	3.8	6.3	2.9	2.5	2.3
	I_2	3.6	4.8	4.9	2.9	2.5

Table 3. Mean values of NO_3-N concentration (ppm) after first irrigation and application of urea.

Treatment		Soil Depth (cm)				
		0-30	30-60	60-90	90-120	120-150
N_1	I_1	9.6	7.9	5.7	4.4	2.9
	I_2	3.2	4.5	4.9	6.1	5.5
	I_1	11.1	8.9	6.0	4.2	3.3
	I_2	4.1	4.5	4.8	6.4	6.0

Table 4. Mean values of residual NO_3-N concentration (ppm) after fifth irrigation.

Treatment		Soil Depth (cm)				
		0-30	30-60	60-90	90-120	120-150
N_1	I_1	4.5	5.2	3.6	3.3	2.3
	I_2	2.8	2.9	3.6	4.5	3.8
	I_1	5.7	6.8	4.8	3.4	3.1
	I_2	3.2	3.4	4.1	5.7	4.1

The leached nutrients contact subsurface water and may leave it flabby for drinking reason. Groundwater reservoir will be seriously contaminated if the practice for overuse continues.

Another effort was made to develop regression models for better understanding of the nitrates leaching status in the soil layers under variable dose of fertilizer and depth of irrigation. Regression models urbanized respectively for light the averages of light (I_1) and heavy (I_2) irrigations across fertilizer levels are shown below:

$$Y = 13.05 - 9.280 \times 10^{-2} X + 1.716 \times 10^{-4} X^2 \quad (R^2) = 0.99$$

$$Y = 2.19 - 5.059 \times 10^{-2} X - 1.825 \times 10^{-4} X^2 \quad (R^2) = 0.83$$

Where, Y = Nitrates available at a depth (ppm).
X = Depth of surface irrigation (cm).

For low and high irrigations, respectively, the models predict that nitrate traces will reach 280 and 310 cm soil depth. Although NH_4NO_3 went down to a depth of 160 cm, nitrate concentrations declined at 180 cm depth and almost vanished at 240 and 300 cm depth, according to written reports.

Table 3 also revealed that as fertilizer application rates increased from 125 to 188 kg/ha, NO_3-N concentrations increased significantly in comparison to remaining nitrates in Table 2. The following are the standard techniques for N_1 (125 kg/ha) and N_2 (188 kg/ha) averaged over irrigation regimes:

$$Y = 6.38 + 2.570 \times 10^{-3} X - 1.230 \times 10^{-4} X^2 \quad (R^2) = 0.93$$

$$Y = 7.98 - 1.800 \times 10^{-2} X - 4.370 \times 10^{-5} X^2 \quad (R^2) = 0.97$$

Where, Y = Nitrates available at a depth (ppm).
X = Amount of urea added (kg/ha).

According to the preceding calculations, nitrate building in the subsurface rose as the rate of nitrogenous delivery increased, peaking in the 0-30 cm depth. The NO_3-N content in soil was again significantly different for the two levels of irrigation as well as fertilizer doses following the last (5th) irrigation in the wheat field (Table 4). The NO_3-N content in the subsurface followed a similar pattern to that observed following the first irrigation. NO_3-N travelled up to 230 cm soil depth in light and extensively irrigated plots, according to the mathematical models generated from the final data.

3. Industrial Pollution of Water

Water contamination is primarily caused by household and industrial trash. Industrial wastewaters represent a variety of concerns to waterbodies, including potential dangers, sanitary hindrances, and other issues (Mansour *et al.,* 2018). Water is an essential component for human vital functions such as feeding, metabolism, absorption, evacuation, and procreation (Kılıç, 2020). The discharge of industrial effluent into waterways leads in substantial groundwater contamination. The pollutants can contain crop or livestock manure, chemicals, alkaline solutions, lubricants, and organometallic compounds, among other things, synthetic detergent, or radioactive substance, some of which may be toxic (Filote *et al.,*2021). Faisalabad city is known for its textile industry which involves calendaring, printing, and dyeing works. Nearly 1.43 million cubic meters of untreated effluent are being disposed of into natural streams from these industrial units. Metals like zinc, copper, manganese, iron, nickel, and lead are involved in calendaring, finishing, printing and dyeing processes (Gerber *et al.,*2010). Unlined drains are the major source of pollution to ground water. However, the problem was less severe along the lined section than unlined zone. Insufficient capacity of drains causes over-spilling of heavily polluted water around the drains which results in formation of permanent ponds of water (WWF, 2019). The water in these ponds is either evaporated to the open atmosphere or leached down into the ground water. To prepare an Environmental Impact Statement for heavy metals, Zn Fe, Cu, Mn and Pb, three locations; one at the end of Faisalabad city area (Station 1), second near the end of the lined section of sullage carrier (Station 2) and third near the end of sullage carrier (Station 3) were selected for discharge measurements and collecting wastewater samples. Daily discharge measurements were made at each station using Current Meter for a week. The difference of inflows and outflows were used to calculate the seepage losses of wastewater in lined and unlined sections of the sullage carrier separately. Sewage water samples were collected from the sullage carrier at two stations (1&3) for seven consecutive days for metal analysis. Metal balance in the study area along the sullage carrier was calculated by using difference of quantity of each metal coming in at station 1 and quantity of that metal going out at station 3. The quantity of metal (tons/year) was obtained by multiplying the concentration of metal (mg/l) in the effluent by the discharge of the effluent (l/S) at respective station.

To analyze the water samples Lindsay and Norvell procedure was adopted. Atomic Absorption Spectrophotometer (Pye Unicam SP 9 model) was used for determining the contents of the metals.

Table 5. Distribution of Heavy Metals by Distance in Unlined Section of the Sullage Carrier

Parameters		Distance from Sullage Carrier (meter)						
		<25	25-50	50-100	100-150	150-200	200-300	>300
		Percent Samples						
Zn	HDL	25.00	42.86	58.58	61.53	97.81	100.00	100.00
	MPL	75.00	57.14	41.42	38.47	2.19	0.00	0.00
	TL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	HDL	0.00	0.00	0.00	0.00	21.29	36.13	98.21
	MPL	0.00	0.00	21.23	39.00	52.45	60.45	1.79
	TL	100.00	100.00	78.77	61.00	26.26	3.42	0.00
Cu	HDL	0.00	0.00	0.00	0.00	0.00	0.00	50.00
	MPL	12.70	14.29	0.00	0.00	0.00	7.89	16.67
	TL	87.22	85.71	11.12	27.29	41.29	72.32	83.33
Mn	HDL	0.00	0.00	0.00	0.00	0.00	7.89	16.67
	MPL	0.00	0.00	11.12	27.29	41.29	72.32	83.33
	TL	100.00	100.00	88.88	72.71	58.71	19.79	0.00
Pb	HDL	0.00	14.29	66.67	81.51	94.00	100.00	100.00
	MPL	25.00	57.14	33.33	18.49	6.00	0.00	0.00
	TL	75.00	28.57	0.00	0.00	0.00	0.00	0.00

Table 6. Analysis of Ground Water Samples Collected Along Unlined Section of Carrier.

Parameters	Average Conc.	Maxi.	Mini.
	mg/1		
Zinc	4.40	10.94	1.02
Iron	3.63	7.85	0.63
Copper	1.92	4.98	0.74
Manganese	3.24	5.66	1.10
Lead	0.08	0.70	0.00

3.1 Ground Water Contamination along Sides of Unlined Section of the Sullage Carrier

The results of the chemical analysis of ground water samples were compared with the international standards of drinking water defined by WHO to assess their suitability for human consumption (Water-Quality-Status-of Major-Cities-of Pakistan). Table 5 shows the distribution of different metals by distance in the vicinity of unlined section of the sullage carrier.

The maximum, minimum and average concentrations of all the metals in water samples collected along unlined section of the sullage carrier are presented in Table 6.

3.2 Ground Water Contamination along Sides of Lined Section of the Sullage Carrier

For the lined section the concentration of heavy metals varied considerably as contrasted with the samples obtained from the corresponding distance ranges of the unlined section of the sullage carrier (Table 7). The table shows that there was no Zn problem in lined section, as no sample was found within TL. It is nice to note that the impact of distance of the pumping device from the pollution source was more pronounced in the unlined section compared with lined section of the sullage carrier.

Table 7. Distribution of Heavy Metals by Distance in Lined Section of the Sullage Carrier

Parameters		Distance from Sullage Carrier (meter)						
		<25	25-50	50-100	100-150	150-200	200-300	>300
		Percent Samples						
Zn	HDL	71.43	88.00	93.14	79.00	100.00	100.00	100.00
	MPL	48.57	12.00	6.86	21.00	0.00	0.00	0.00
	TL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	HDL	0.00	0.00	0.00	0.00	0.00	30.12	45.00
	MPL	0.00	33.33	57.14	88.00	100.00	69.88	55.00
	TL	100.00	66.67	42.86	12.00	0.00	0.00	0.00
Cu	HDL	0.00	0.00	18.57	26.77	33.33	100.00	100.00
	MPL	39.90	52.71	57.14	66.56	66.67	0.00	0.00
	TL	60.10	47.21	24.29	6.67	0.00	0.00	0.00
Mn	HDL	0.00	16.11	24.29	37.29	100.00	100.00	100.00
	MPL	39.75	33.12	42.67	52.71	0.00	0.00	0.00
	TL	60.25	50.77	33.04	10.00	0.00	0.00	0.00
Pb	HDL	80.00	100.00	58.71	100.00	100.00	100.00	100.00
	MPL	20.00	0.00	14.29	0.00	0.00	0.00	0.00
	TL	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The maximum, minimum and average concentrations of all the metals in water samples collected along lined section of the sullage carrier are shown in Table 8.

Table 8. Analysis of Ground Water Samples Collected Along Lined Section of the Carrier

Parameters	Average Conc.	Maxi.	Mini.
	mg/l		
Zinc	2.34	5.84	0.86
Iron	0.94	2.36	0.50
Copper	0.94	2.21	0.51
Manganese	1.52	3.40	0.98
Lead	0.00	0.06	0.00

Conclusions

The study resulted in the following conclusions:

* The seepage loss of unlined section of the sullage carrier was 3.5 times more than the seepage loss in the lined section.
* The measurement of the metal balance showed that Zn was at the top with 136.87 followed by Mn Cu, Fe and Pb with 82.28, 66.26, 52.57 and 7.88 tons/annum, respectively.
* Results indicated that sullage carrier has contaminated the ground water up to 300 meters along lined section of the sullage carrier. Iron, copper, and manganese were the major pollutants in contaminating the ground water.

Recommendations

* No pumping device be installed within a radius of 400 meters in unlined section and 200 meters in lined section from such sullage carrier.
* A policy needs to be worked out for the massive lining of the unlined sullage carriers to reduce the degree of contamination by heavy metals.
* The industrial effluent must be treated before discharging into drains.
* It should be made compulsory for every industrial unit to have action plans, setting target for what to achieve for pollution control during a year.

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