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Assessment of Water Quality of Rural Areas of District Kasur and Its Influence on Waterborne Pathogenesis and Floral Bioaccumulation

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Abstract

All of forms life needs water to survive. Therefore provision of clean water for consumers either for drinking or for irrigation purpose is necessary. But nowadays the quality of water is deteriorating day by day due to exposure of several contaminants like domestic and industrial solid waste and effluents, different microbial pathogens and toxic chemicals which frequently cause waterborne pathogenesis and diseases in Pakistan. In current study, the water samples from tehsils of district Kasur were collected which is considered as an industrial hub and center of agriculture and much populated too. That is why; different physiochemical and microbial parameters of water samples of tap, filter plants, tube well and canals of Kasur region were examined. In these parameters the pH, turbidity, hardness, acidity of water, alkalinity of water, total dissolved solids, microbial contamination, level of bioaccumulation and many other factors were observed. A hospital based survey was also performed to gather information about the waterborne diseases. The obtained results showed that the values of some parameters were within permissible limit whereas some of them were not according to the WHO standard. It was concluded that the water of district Kasur is not good for drinking and irrigation purposes. In this regard a proper guideline should be provided to the general public by government and private sector concerned departments to improve public health of selected region.

Keywords: Water; Kasur; waterborne pathogenesis; bioaccumulation; public health.

1. INTRODUCTION

Water is considered essential for any form of life. Though three parts of earth surface is covered by water bodies still globally there are limited sources of water are present that can be used for drinking purpose and irrigation. Parallel to this, the demand of water is gradually increasing day by day due to increase in human population [1]. But reported data showed that there are several microorganisms which are responsible for the water borne diseases like fungi, bacteria, algae, helminthes and protists etc. The presence of such microbial flora makes the water unfits for use either to drink or irrigate. Another potent factor of water contamination is presence of fertilizers, pesticides, herbicides, solid waste, municipal drainage and industrial effluents which not only cause water pollution but also lowers its quality [2].

That is why; to estimate the quality of the water sources which are frequently utilized for drinking and sometimes for irrigation purposes, their different physiochemical and microbial parameters are determined. Among the physiochemical parameters usually water hardness, turbidity, pH, nitrate level, electrical conductivity, amount of phosphate and heavy metals are determined whereas to detect microbial contamination, usually the coliforms (fecal matter bacteria) are checked [3]. In this regards, the reported data of Pakistan indicates that only 20% of available water is safe to consume while rest of the water of different sources is highly contaminated and if same practice of unawareness and poor hygiene will be continued, it will repeatedly cause water borne pathogenesis in consumers and also issues of bioaccumulation. The leading root causes of this water pollution are improper sewerage system, herbicides, fertilizers and industrial effluents' addition in water bodies [4].

As Pakistan is a developing country and it has the poor sanitary conditions and lack of knowledge related to water pollution and waterborne health issues among general public. In many cities and rural areas of Pakistan, either mixing of industrial effluents or seepage of sewerage water is common due to which several diseases have been reported in clinical data like typhoid, dysentery, diarrhea and jaundice in public since long time. Same is the situation of district Kasur and its nearly rural areas which are consider as one of the leading industrial hub but so far no proper data have been published yet. That is why; current experimental study was performed to check quality of drinking and irrigation water along with level of bioaccumulation and a local hospital based survey to highlight the level and possible health hazards of polluted water consumption [5-7].

2. MATERIALS AND METHODS

2.1 Sample Collection

For this research work, the total 16 samples of drinking and irrigation water were collected from sources: tap, canal, filter and tube well. The sites of collection were tehsils of Pattoki, Kasur, Chunnain and Kot Radhan Kishan. At first, codes were assigned to these collected samples and then analysis of their microbial and physicochemical parameters was done.

2.2 Determination of pH

The pH of all collected water samples was estimated by using pH meter at room temperature in triplicate manner then a mean value was calculated [8].

2.3 Estimation of Electrical Conductivity

A Jenway 4010 was used to measure the electrical conductivity of drinking and irrigation water samples. When the reading became stable then conductivity was measured in μScm^{-1} [14, 15].

2.4 Evaluation of Hardness of Water

The standard titration method was used to determine the hardness of water and the hardness of water was calculated by using following formula:

Total hardness as $CaCO_3$ (mg/L) = v_1 x 1ml EDTA solution x 1000/sample to be used

B= 1 (1ml EDTA solution) = 1mg $CaCO_3$ = 0.01M

Temporary hardness was removed by the boiling process and then again water was titrated to note permanent hardness of water [9]:

Permanent hardness (mg/L) = v_2 x 1ml EDTA solution x 1000/ml samples to be applied

Tentative hardness= Total hardness – permanent hardness

2.5 Determination of Turbidity Level

The turbidity meter was used to measure the turbidity of water (Nephalometic Turbid meter) HI83414 HANNA instrument. The readings were recorded in Nephelometric Turbidity Units (NTU) [10].

2.6 Determination of Total Dissolved Solids (TDS)

The probe of a conductivity multi-meter was used to measure total dissolved solids and readings were noted [11, 16].

2.7 Detection of Heavy metals in Water

To check the concentration of arsenic in water the Arsenic kit HC024461 was used. The results were noted in mg/L by using following formula [12]:

Result of analysis = measurement value x dilution factor

Whereas the concentration of chromium was determined by using spectrophotometry method. All the samples were filled in the cuvette cell one by one and placed in the spectrophotometer to take the absorbance reading [13].

2.8 Evaluation of Acidity of Water

The standard titration method was used to measure the acidity of water. The total acidity of water samples was calculated by using following formula:

Total acidity = Volume of NaOH used in (ml) x 1000/volume of sample (ml)

2.9 Estimation of Alkalinity of Water

The total alkalinity of all samples was also determined by using titration method. Final reading was calculated by using following formula:

Total alkalinity = Reading x 1000/volume of sample (ml)

2.10 Analysis of Salt

Salt analysis was done with the help of 861 Advanced Compact IC Metrom. The sample which was to be analyzed was inoculated into an eluent [17].

2.11 Detection of Microbial Contamination

In all sterilized petri plates 20ml of nutrient agar was poured and solidified. Then 1ml of sample was inoculated for spreading. All the Petri dishes were incubated at 37° C for 72 hours. After that the plates were examined to count colony forming units (CFU/ml), size of colonies and other morphological features for probable identification. Whereas to detect the coliform bacteria same procedure was followed but eosin methylene blue (EMB) agar was used as selective medium [18].

2.12 Hospital based survey at DHQ Kasur

A hospital based survey was done at DHQ Kasur to gather information about the different types of water borne diseases in district Kasur. A performa was designed to estimate the different diseases in district Kasur. This task was completed in three months and total number of patients per day was determined [19].

2.13 Detection of Bioaccumulation in Plants Samples

The level of bioaccumulation in different vegetables samples of ridge gourd, spinach, pumpkin and bringal was determined. The pieces of these vegetables were cut and dried in oven at 110° C for 2 hours. The obtained residues were ground well. After that for overnight pre-digestion at room temperature, 1 g of sample was taken in the beaker and 5ml of HNO_3, 1 ml of H_2SO_4 were also added. Later on, samples were analyzed by using the flame adsorption spectrophotometry [33].

2.14 Detection of Salt Analysis

Salt analysis of water samples was performed by using 861 Advanced Compact IC Metrom [34].

2.15 Statistical analysis

The obtained data was analyzed by using one way single factor analysis of variance (ANOVA) [20].

3. RESULTS AND DISCUSSION

3.1 Determination of pH

Though ideal range of pH of drinking and irrigation water is 6.7 to 8.4 but if pH value decreases below 5 or rises above 8.3, it is considered hazardous. The obtained results were within this standard range and were not found statistically significant (Table 1) but usually major factors which may alter pH value of water includes the presence of minerals, industrial effluents usually containing heavy metals and algal blooms etc [22, 35].

3.2 Estimation of Electrical Conductivity

The maximum obtained electrical conductivity value was 2451.8 µs/cm of tube well water whereas minimum obtained reading was 1021.5 µs/cm of canal water (Table 1). This variation in electrical conductivity (EC) usually occurs due to the presence of salts and total dissolved solids in water. So the amount of solid particulate matter is found in water sample, it is directly proportional to the value of electrical conductivity. Another influential factor is temperature of water that is why; for tube well water sample showed higher value of electrical conductivity was noted [23, 36].

3.3 Evaluation of Hardness of Water

The obtained results (Table 1) showed that comparatively canal water had higher hardness level (172 mg/L) whereas minimum value of hardness was obtained for tube well water (103mg/L). According to the standards of WHO the levels of water hardness are for: soft water 61-120 mg/L, normal hard 121-160 mg/L and the too much hard water 180 mg/L. So to avoid the health complications, the use of soft water is advised than water sources with greater levels of hardness [24, 37].

Table 1: Physicochemical observations of the selected water samples of district Kasur

Sample	pH	EC (µs/cm)	Hardness (mg/L)	Turbidity (NTU)	TDS (NTU)	Heavy metal (% of Arsenic)	Acidity (ml)	Alkalinity (ml)
Canal water	7.27 ± 0.17	1021.5 ± 420.42	172 ± 44.40	0.37 ± 0.09	286.25 ± 71.71	30 ± 4.08	150 ± 27.39	287.5 ± 100
Tube well water	7.38 ± 0.19	2451.8 ± 977.5	103 ± 34.35	1.54 ± 0.31	431 ± 95.75	20 ± 10	150 ± 29.72	390 ± 94.20
Tap water	7.42 ± 0.19	1086 ± 455.5	111 ± 26.60	0.43 ± 0.11	992.75 ± 291.01	20 ± 14.14	152.5 ± 38.38*	300 ± 69.40
Filtered water	7.98 ± 0.19	1128.8 ± 326	146.53 ± 273.3	3.05 ± 2.30	703.5 ± 176.30	55 ± 26	27.5 ± 8.54	567.5 ± 135.98

* Mean ± S.E.M values are mentioned and one way ANOVA results were found significant at 5% level of significance (*)

3.4 Determination of Turbidity

For turbidity the lowest obtained value was for canal water which was 0.37 NTU and highest for filtered water was 1.54 NTU (Table 1) whereas the standard value of consumable water turbidity should be less than 5 NTU but this variation in readings occur according to the level of how much clear, a liquid is. Thus obtained higher value indicated that filter plant was might be out of order [25, 38].

3.5 Calculation of Total Dissolved Solids (TDS)

According to the obtained results, maximum total dissolved solids were found in tap water 992.75 mg/L whereas minimum amount was present in canal water which was 286.25mg/L. these variations occur usually due to the presence of minerals of inorganic and some of organic salts like potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates, sometime the industrial and domestic waste too [21, 39].

3.6 Detection of Heavy Metals in Water

The observations showed that chromium was not detected in selected water samples whereas the minimum percentage of arsenic was found in tube well and canal water which was (20%) while its maximum concentration was found in filter water (55%). These observations clearly depicted that the water source was loaded with industrial effluents which was further supplied to filtration plant without any prior treatment and high percentage of heavy metals may lead to carcinogenesis [25, 40].

3.9 Evaluation of Acidity of Water

The statistical result of Acidity of tap water was found significant (152.5 ml) at 5% level of significance whereas the other collected water samples of canal and tube well has (150ml) of acidity level while lowest level of acidity was recorded for filter water was (27.5ml). This acidity level rises in drinking and irrigation water due to the exposure of acidic drainage water and sometimes due to excessive microbial growth [26, 41].

3.10 Estimation of Alkalinity of Water

The result of filtered water sample showed 567.5ml of alkalinity level whereas the minimum value was noted for canal water sample of 287.5ml. These variations in clean water samples occur due to the anthropogenic contamination in water supply available for consumers and its regular use may result in neural disorders and carcinogenesis [27, 28].

3.11 Detection of Microbial Contamination

On nutrient agar, maximum colonies were found in tube well water sample (606 CFU/ml) with larger colonial size of (1.196 mm) (Table 2) and among obtained microbial flora, *Streptomyces scabies, Bacillus weihenstephanensis, Pseudomonas putida, Pantoea agglomerans, Ar. dextranolyticus, Bacillus simplex, Microbacterium oxydans, Pantoea agglomerans, Ps. Cedrella, Staphylococcus epidermidis, Escehersia coli, Lactobacillus spp.* and *Bacillus cereus* were identified which represented the poor quality of drinking and irrigation water and the utilization of such water sources may lead to waterborne pathogenesis. It showed the water pipes and tanks were not regularly washed with chlorine [31, 41].

Whereas on selective medium of eosin methylene blue (EMB) agar, coliforms were isolated which included *Str. vtolaceonbidus, Ps. jessenn, B. subtilis, Pa. agglomerans, Ps. putida, Vibrio cholerae, Shigella sp., S. typhi, Campylobacter, Escherichia coli, Cryptosporidium parvum, Entamoeba histolytica, Giardia spp.,* and *Balantidium coli.* The maximum number of coliforms were observed in filtered water sample (530 CFU/ml) while for colonial size larger diameter colonies were also obtained (Table 2) in same water sample (0.98 mm) which was a clear sign of sewerage water seepage in clean water and it may cause health complications in consumers [32, 33].

Table 2: Observations of microbial contamination detection in selected water samples

Sample	On nutrient agar		On EMB agar	
	CFU/ml	Size of colonies (mm)	CFU/ml	Size of colonies (mm)
Canal water	549 ± 30.74	0.711 ± 0.151	497 ± 85.74	0.74 ± 0.13
Tap water	525 ± 35.20	0.784 ± 0.15	472 ± 56.70	0.97 ± 0.15
Tube well water	606 ± 97.16	1.169 ± 0.210	480 ± 53.79	0.91 ± 0.17
Filter water	510 ± 37.48	0.722 ± 0.143	530 ± 39.37	0.98 ± 0.15

* Mean ± S.E.M values are mentioned and one way ANOVA results were not found significant.

3.12 Hospital based survey at DHQ Kasur

In this hospital survey of 3 months, daily reported data of common waterborne infections like diarrhea, dysentery, jaundice, typhoid, and cholera was collected (Table 3) from DHQ Kasur. The one way ANOVA results of number of patients per day were found significant for typhoid (1195) at the 0.1% level whereas the minimum number of patients were reported with dysentery (395) which was quite alarming that consumers of this selected district were utilizing water either of tap, tube well, canal or filtered one, each water source was loaded with microbial contamination and people even did not follow the hygiene practice like use of boiled or potash alum treated water and another possible root cause was found poor sanitation [29].

Table 3: Observations of selective hospital based survey on waterborne diseases

Waterborne disease	No. of Patients/day
Diarrhea	556 ± 40.73
Dysentery	395 ± 19.05
Jaundice	551 ± 102.3
Typhoid	1195 ± 170.41*
Cholera	1125 ± 124.80

*Mean ± S.E.M values are mentioned and one way ANOVA results were found significant at 0.1% level of significance (*).

3.13 Detection of Bioaccumulation in Plants Samples

The trace elements were detected in the edible vegetables like bringal, ridged gourd, spinach and pumpkin which were irrigated with the canal water and tube well water. But due to the dumping of industrial waste and effluents in agricultural lands and nearby water bodies and sometimes the over dosage of fertilizers, disturbs the balance of trace elements in soil and vegetables [42]. Following trace elements were detected in selected samples:

Cadmium: It is not only harmful for human beings but also for plants and animals. It should not be found in vegetables but the detected amount was in spinach (0.25 mg/kg) > bringal (0.19mg/kg) > ridged gourd (0.17mg/kg) > pumpkin (0.03mg/kg) which was quite alarming (Table 4). The bioaccumulation of cadmium in plants causes imbalance of homeostasis and pH, may also results in altered structure of roots and consumption of such cadmium loaded vegetables causes several health complications [43].

Table 4: Observations of the trace elements vegetables samples of district Kasur

Vegetables	Cd (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Ni (mg/kg)	Zn (mg/kg)	Cr (mg/kg)	Cu (mg/kg)
Bringal	0.19 ± 0.014	20.77 ± 0.71	162.30 ± 1.25	1.08 ± 0.17	31.75 ± 1.25*	1.34 ± 0.22	22.23 ± 0.37
Ridged Gourd	0.17 ± 0.036	21.20 ± 1.02	118.25 ± 1.49	1.40 ± 0.20	22.94 ± 0.45	2.72 ± 0.18	18.18 ± 0.19
Spinach	0.25 ± 0.007*	122.35 ± 1.24	836.50 ± 7.30*	3.40 ± 0.31	9.50 ± 0.20	5.31 ± 0.27*	21.20 ± 0.60
Pumpkin	0.03 ± 0.002	30.81 ± 0.65	349.15 ± 4.85	4.01 ± 0.01*	15.70 ± 0.29	1.67 ± 0.19	42.75 ± 0.85*

*Mean ± S.E.M are mentioned here and one way ANOVA results were found significant at 0.1% level of significance (*)

Manganese: According to the FAO/ WHO, the permissible amount of manganese is 0.2 mg/kg for vegetables but in obtained results the amount of manganese exceeds the limit so in spinach (122.35mg/kg) > pumpkin (30.81 mg/kg) > ridged gourd (21.20 mg/kg) > bringal (20.77 mg/kg) was observed (Table 4). Manganese toxicity occurs in plants due to poorly drained and acidic soils. As an outcome, sub cellular localization of manganese occurs in plants [44].

Iron: The obtained amount of iron content in Spinach (836.50 mg/kg) and pumpkin (349.15 mg/kg) were found significantly beyond standard range of 50-250 mg/kg while in bringal (162.30 mg/kg) and girded gourd (118.25 mg/kg) were within range (Table 4). This alleviated iron induced toxicity destroys antioxidant based defense systems of plants, alters metabolic reactions and disrupts other structural and functional activities in plants and also results in health complications in consumers [45].

Nickel: All the samples were found loaded with nickel content (Table 4) and crossed the standard level of 0.1 mg/kg defined by FAO/ WHO. Though low concentration of nickel is considered essential for plant growth i.e., enzymatic function, nitrogen metabolism, iron uptake, and specific metabolic reactions at but human activities like industrialization, excessive use of fertilizers, pesticides and addition of sewage sludge in the environment have disrupted the ecological balance. But nickel toxicity reduces seed germination, root and shoot growth, biomass accumulation, chlorosis, necrosis and inhibits photosynthesis, transpiration and causes oxidative damage in plants and consumers of such vegetation suffer too [46].

Zinc: The results (Table 4) of vegetables were within tolerable range of FAO/ WHO which is 99.4 mg/kg. It is also considered as essential trace element for consumers' balanced metabolism and homeostasis like functioning of small intestine [47].

Chromium: Spinach samples indicated the maximum amount (Table 4) of chromium bioaccumulation (5.31mg/kg) because it is leafy in texture and has more surface area for absorption. While standard limit for its concentration is 0.002 to 0.1 mg/kg by FAO/ WHO but utilization of garbage loaded with chromium in agricultural fields is consider now a days a major source of chromium pollution [14, 28].

Copper: The samples of pumpkin (Table 4) were found with maximum concentration of copper (42.75mg/kg) whereas minimum amount was present in ridged gourd (18.18mg/kg). Though obtained results were with defined limits of FAO/WHO (73 mg/kg) for copper concentration in plants. Usually plants have been found deficient for normal development so it is compensated by either by artificial or organic fertilizers. Similarly, at level of consumers, it acts as a biocatalyst and is required for balanced body pigmentation [48].

3.14 Detection of Salts in Water samples

The results of this analysis indicated that NO_2 was totally absent in all samples. The most abundant form of salts was chlorides even sample tap water KrK crossed the permissible limit of 250mg/L for chlorides by FAO/WHO and it was (Table 4). The major root cause of variation in levels of these salts is mixing of sewerage water in clean water and exposure of other pollutants like industrial waste and effluents, run off of fertilizers from fields and often results in form of syndromes and serious health issues of infants [49].

Table 4: Salt analysis of drinking and irrigated water of District Kasur

Sample	Fluoride (F^-) (mg/L)	Chloride (Cl^{2-}) (mg/L)	Nitrite (NO_2) (mg/L)	Nitrate (NO_3) (mg/L)
Tap. Kasur	0.3	45	_	_
Canal. Kasur	_	4	_	_
Filter. Kasur	0.3	46	_	_
Tube. Kasur	0.5	28	_	_
Tap. KrK	_	585	_	_
Canal. KrK	_	84	_	45
Filter. KrK	_	20	_	0.8
Tube. KrK	_	2	_	_
Tap. Chunnian	_	77	_	38
Canal. Chunnain	_	79	_	20
Filter Chunian	0.1	3	_	16
Tube. Chunnain	_	137	_	
Tap. Pattoki	_	82	_	_
Canal. Pattoki	_	94	_	210
Filter Pattoki	_	5	_	_

4. CONCLUSION

The conclusion of this physicochemical and microbial parameters based study was that water samples of tap, tube well, filter and canal sources from four tehsils of Kasur district were found contaminated with sewerage water, run off fertilizers and industrial effluents [50]. That is why; for some of selected parameters showed deviation from defined standards of drinking and irrigation water. So these water sources were found inappropriate for drinking and irrigation but residents are facing lack of awareness yet and frequently also suffer from waterborne pathogenesis and other health complications by consuming bioaccumulated local vegetation. Thus, proper general public awareness should be provided related contaminated water by government and private sector concerned departments to protect them from the water borne diseases and their harmful effects in the irrigation sector.

Conflict of Interest: Authors have no conflict of interest.

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