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Microbial Degradation of Water Pipelines and Effects of Polluted Water on Human Health

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A B S T R A C T

The degradation of water supplies is linked with poor anthropogenic activities. This study determines that contamination of water supply occurs because of destabilization of pipe material and deposits in the water distribution system due to physiochemical and microbiological processes that have developed over decades and cause health issues (Hepatitis C, and GIT disorders) which result in the death rate of 3.4 million people over the globe. This study was conducted in Gujrat, Pakistan and the primary source of data collection was a survey questionnaire while secondary sources involved a comprehensive literature review. ANOVA test, Correlation, and reliability analysis were applied to test the variables. The results of this study revealed that contaminated water supplies, oxyhydroxide products of corrosion, the mixture of sewage, and industrial effluents were significantly associated with the contamination of water supplies. The findings of this study also explore the contamination of household store water (HSW), contaminated water supplies, and the mixture of sewage, and industrial effluents that were responsible for water contamination, whereas; the condition of underground water supply pipelines was very worse. The use of upgraded water supply systems and water purification technologies is a common global practice that would be useful to reduce water supply contamination. The findings of this study will contribute to the literature on water supply contamination, the framework of water quality parameters, and low-cost adaptable water treatment techniques.

Keywords:Anthropogenic, Microbiological processes, Oxyhydroxide, Industrial effluents, Water quality, Purification technologies

1. Introduction

Water contamination is a common global issue that poses human life a risk of unsafe drinking water (Ajala, O. J., 2020). Water pollution is the discharge of polluted water from industrial waste, polluted sewage water, and agriculture fields (Salem, A., 2019). The contaminants in water depend on the topography and the land use through which water travels while reaching the water supply system (Jain, R. 2012). It depends on the underground recharge of the water and the soil through which rainwater reaches groundwater. The groundwater moves through different rocks and soils and takes along a range of compounds like magnesium, calcium, arsenic, chlorides, nitrates, and iron (Watson, C., 2006). The elements that occur naturally in groundwater can contaminate it if they exceed their permissible limit (Bolto, B., et al., 2002). The contamination of the water supply occurs because of damaged water pipelines, and toxic metals, e.g. lead, mercury, and chlorine. The pipe material influences the quality of water as lead pipes are more vulnerable to health and destroy water quality (Broo et al., 2001). The quality of water is affected by anthropogenic activities (i.e. urbanization and industrial activities) and natural processes (Prüss, A., et al., 2002). These activities frequently caused the deterioration of water quality, physical alternation, and biological changes in freshwater (Yayintas, O. T., et al., 2007). This is responsible for increased water pollution. The rapid phases of industrialization, population growth, and extension of urbanization have contributed to the severity of water pollution (Lin, S. H., 2002; Esplugas, S. et al., 2002). About 70-80% of the diseases are caused because of the pollution of fresh water and the contamination of water in developing countries (Wang, M. et al., 2011; Nweke, O. C., 2009). This polluted water is infectious, particularly for women and children. Each year, diarrhea causes over 1.5 million infants and children to die because of a lack of safe drinking water (Malik, Q. A., and Khan, M. S., 2016). The demand for clean water requires effective and sustainable industrialization, a good ecosystem, and reasonable consumption. Recycling is suitable to treat water, which can be used for aquaculture and in the agriculture fields. The problems that are caused by the lack of safe drinking water make us realize the value of safe drinking water and efficient sanitation systems (Tan, B. H., et al., 2000). At the globe, the scarcity of clean water is expected to cause about 4% of total mortality in the developing world (Pala, A., and Tokat, E., 2002). Therefore, the waterborne disease also remains a cause of concern in developed countries (Güler, C., et al., 2002). Wastewater alters the chemical

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composition and temperature of the water (Sathanarayanan, U., 2007). Sewage waste contains about 99% water and 1% of solids (Gupta, V. et al., 2012). The sewage water contains mainly toxic substances, heavy metals, and pathogenic organisms (Zouboulis, A. I., et al., 2002). Therefore, it is an essential need to purify and treat water (Igwe, J., and Abia, A. A. 2006). Water pollution can be controlled by using advanced technology, such as filtration, activated sludge, microbial reduction, adsorption, aerobic and anaerobic treatment methods (Bell, J., et al., 2000). These technologies require financial aid to purify water (Bhargava, A., 2016). However, the adsorption method is beneficial because of accessibility, ease of operating, and simple design (Gazso, G. L., 2001). The economy is growing, and the population is rising across the world, but now the main slogan of all nations should be "Save Water" (Salem, A., 2019). Water sustainability depends upon the awareness related to these water-borne problems, the public attitude, and concern towards the supply of safe drinking water (LaPara, T. M., et al., 2000). In less developed areas where sanitation and other facilities are not properly designed, people have to rely on hand pumps and bore wells by installing electric motors (Patrick, L., 2003). In Pakistan, it has become a significant problem for people to access safe drinking water because of overpopulation (Nasir, A., et al., 2012).

2. Occurrence of contamination in water supplies

The poor quality of water supplies in water distribution system is primarily because of lead and copper concentration in water. According to the U.S. Environmental Protection Agency (USEPA), it was standard protocol throughout the 20th century to use lead pipes for commercial and domestic water supplies. These pipelines were damaged because of lead concentrations in water, increasing concentrations of organic, and inorganic contaminants with various microorganisms, and the duration of water stay in these pipelines (Wahman, D. G., et al., 2021; Enning D, and Garrelfs J., 2014). All these happening are because of physical, biological, and chemical reactions in water throughout its passage from the water supply system to the consumer as shown in figure 1. These alterations in water quality might be of a greater or shorter magnitude and may cause the development of deposition or sludge which contribute to a bad or pungent smell and foul taste of water (Wang H, et al., 2014). This phenomenon also happens because of deposits of sediments on the pipe wall (oxyhydroxide products of corrosion, water solids, and organic sediments), the flow of water, water age, water consumption, pH of water, and hardness of water (Chu C, et al., 2005). The water supply system must be analyzed as a distinctive biocenosis (a very multifaceted biochemical reactor in which the whole series of interrelated reactions exists).

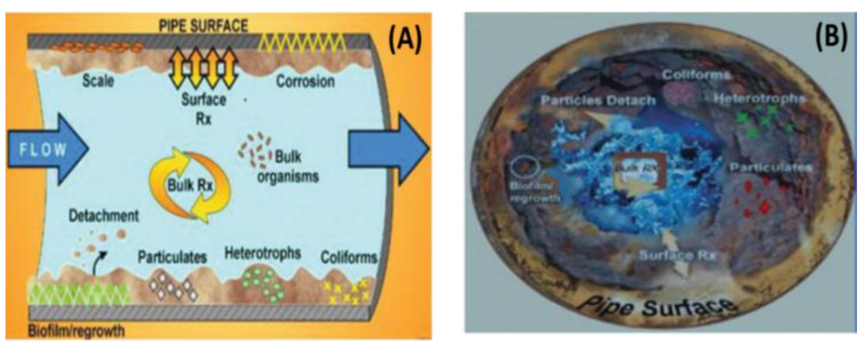

Fig. 1 - (a) Cross section; (b) Water pipe as biochemical reactor

2.1 The Corrosivity in water pipelines system

The severe effects of corrosion in the water distribution system are includes; capacity loss, water leakage, and decay of the chemical and microbiological quality of water (Videla HA, 2001). The procedure of corrosion may involve many factors within the water supply system, such as; pH value of water, buffer capacity, water flow, water temperature, oxygen concentration, and electrical conductivity. The water corrosion is measured by the low pH (acidity), dissolved oxygen, and minimum mineral content. Adjusting the alkalinity and pH is useful for corrosion control. To control lead and copper discharge, phosphate-based corrosion inhibitors (PBCI) may use. These are compounds that include the orthophosphate, which formed a protective coating with lead and copper ions and has a high propensity to remain in solid state and not dissolve into water (Turek, N. F., 2016). The water supply should be protected from contaminants and disinfectant residual concentrations must be set aside within a local determined range without facing any adversity as shown in figure 2

Fig. 2 - Rust and iron corrosion in flint drinking water pipes

3. Research methodology

The exploratory research strategy was selected for this study to define the nature of the problem. The primary source of data collection involved a structured questionnaire, while; the secondary sources included research articles, international reports, and research reviews. It was a cross-sectional population survey that was conducted in 120 household units of the selected area; by using the simple random sampling technique. The contents of the questionnaire used for this study were based on the household questionnaire model (HQM) developed for social evaluation. The questionnaire includes a portion of the source of water, water consumption pattern, and installation of water supply pipeline to evaluate the consumer's dependency on water sources and understanding regarding water supply contamination. Demographic information was included, age, employment, marital status, education, and income. The completed questionnaires were collected and analyzed using Excel and SPSS software. In the process of data analysis, descriptive statistics (frequency, mean, standard deviation, minimum and maximum) were used to define the sample.

3.1. Research objectives

However, the research objectives of this study were;

1. Contamination and Corrosivity of water supply.
2. Health effects and related quality standards of drinking water.
3. Economical treatment techniques for contaminated water.

3.2. Research site

This study was conducted in the area of the Shadman colony, and the Gulshan-e-Rehmat colony of Gujrat, Pakistan as shown in figure 4; while, the coordinates for the Shadman colony are; latitude: 32°35'29.7"N, longitude: 74°03'37.2"E and Gulshan-e-Rehmat colony are; latitude: 32°35'48.5"N, longitude: 74°04'00.1"E respectively. The pipeline of sewage water and underground water became damaged because of rusting of the iron pipeline; therefore, sewage and drinking water got mixed and supplied to the nearby societies. It causes various infectious diseases such as stomach problems and Hepatitis C was mainly observed.

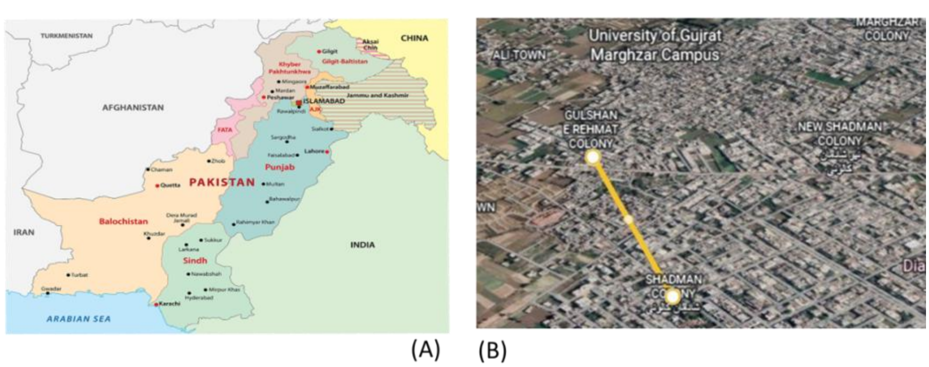

Fig. 3 - (a) Map of Pakistan; (b) Gulshan-e-Rehmat and Shadman colony

The contaminants discharged from the industries and sewage may have toxic effects on human life, and severe impacts on natural and freshwater resources. The industries located nearby these areas were; Service Industry Gujrat, Kamal Cosmetic Company, Khan Electric Industry, Janjua Shoes Industry, Islamabad Marble Factory, and Qazi Industries.

4. Results and discussions

Results were based on several findings that occur after the data collection and data analysis which have been presented in tabular and figure form. This study involves demographics on the basis of the social evaluation model (SEM) to estimate the demographics of the selected area as shown in table 1 and interpreted as well.

Table 1 - Descriptive Analysis of Demographic Information (DI)

Questions	Options	Frequency	Mean	Std. Deviation	Minimum	Maximum
Gender	Male	88	1.2667	.44407	1.00	2.00
	Female	32				
Age group	20-25	17	2.8667	1.24976	1.00	5.00
	26-30	37				
	31-35	25				
	36-40	27				
	>40	14				
Education status	Illiterate	13	2.9583	1.07215	1.00	5.00
	Matric	22				
	Intermediate	52				
	Graduation	23				
	Post-graduation	10				
Marital status	Single	49	2.2417	1.37196	1.00	5.00
	Married	32				
	Divorced	13				
	Widowed	13				
	Separated	13				
Employment status	Full time	22	2.6417	1.15078	1.00	5.00
	Part time	34				
	Student	37				
	Retired	19				
	Unemployed	8				

Table 1 shows the gender status of 120 household respondents; there were 88 males and 32 females who take part in the close-ended, questionnaire-based interview survey. The maximum age group of 37 respondents was from 26 to 30, the highest level of education of 52 respondents was intermediate, and the employment status of the maximum of 37 respondents was employed.

4.1. Contamination of household water supply

The key variables for the assessment of contamination of household water included the sources of water, condition of water supply, water storage tank conditions, and flow of sewage water near houses.

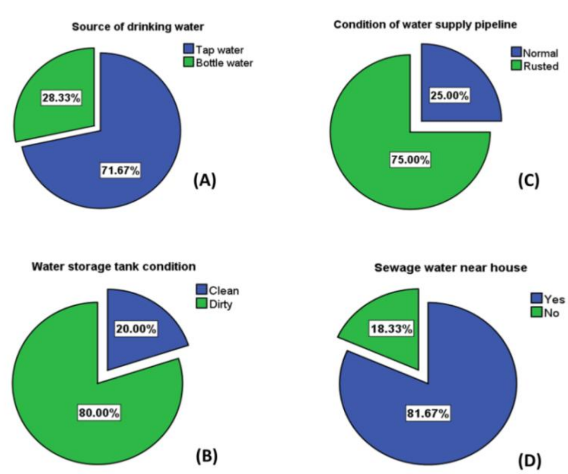

Fig. 4 - (a) Sources of drinking water; (b) Water tank condition; (c) Condition of water supply pipeline; (d) Sewage water near house

In figure 4, (A) shows a maximum of 71% of respondents of the domestic units were using tap water as their source of drinking water, and regular need; (B) shows a maximum of 80% of respondents claimed that their water tanks were dirty because of damaged water supply, dust, and accumulation of sludge substance at the bottom layer of water storage tanks, segment (C) shows that water supply pipelines of a maximum of 75% of domestic units were rusty therefore watercolor was brownish and contaminated, (D) shows a maximum of 81% of respondents had claimed that sewage water flows near their houses. Sewage water is composed of various pollutants such as nitrogen, phosphorus, heavy metals (mercury, cadmium, lead, and copper), and pathogens (bacteria, viruses, protozoa) which cause various diseases in humans such as typhoid and kidney dysfunction.

4.2. Contamination of water supply

The significant variables for the assessment of contamination of water supplies included, the installation period of water supplies which is a significant factor in the contamination of water supply, the presence of pollutants or toxic compounds in water, industrial sewage existence near houses indicates that it would also be mixed with groundwater supplies that are already impaired and may lead to water pollution, use of water purification tablets which are chlorinated water tab in common, and the last one is the complaint about drinking water quality and impair water supply system to the concerned authorities such as WASA, and TMA in Pakistan which directly deals with all such matters. Besides these key variables, other variables such as; the smell of water, taste of water, and color of water were also depicted as the real concern of contamination of the water supply of living communities.

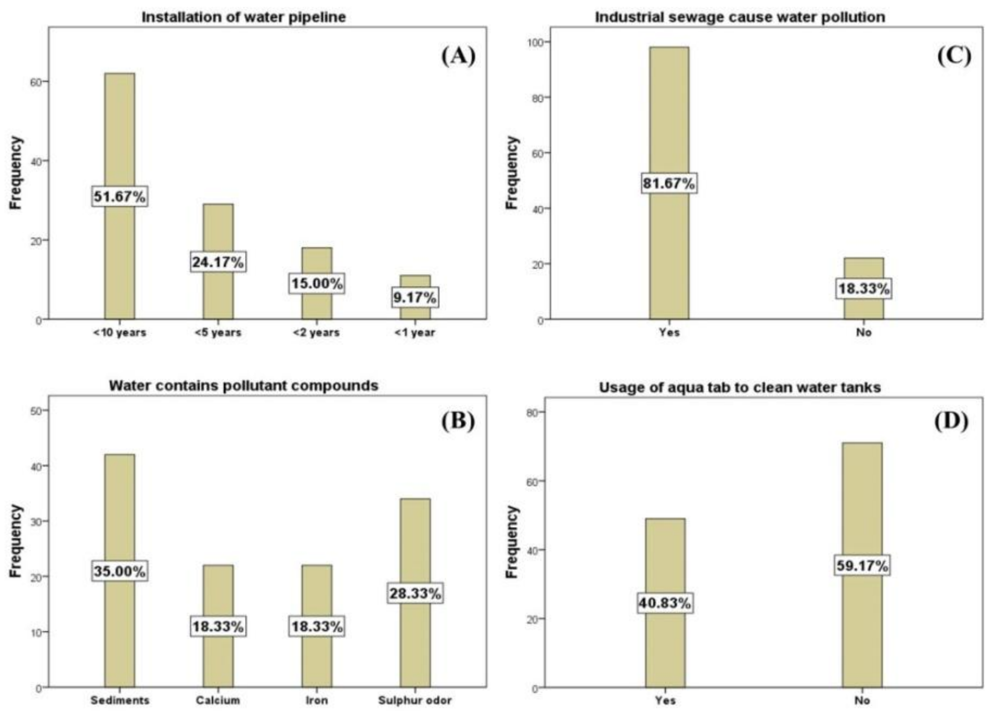

Fig. 3 - (a) Installation of water pipeline; (b) Water contain contaminants; (c) Industrial sewage cause water pollution; (d) Usage of aqua tab to clean water

A maximum of 70% of respondents found smell in water which means that water was contaminated by any reactive contaminant. Almost 37% of domestic units observed that water has some odd taste so water has some pollutants such as lead, mercury, and cadmium which may cause serious health diseases such as gastrointestinal disorders, high blood pressure, and lung damage. A maximum of 68% of domestic units observed that water was dirty, brownish, and yellowish, which predict that water quality was not better for consumption of water for domestic consumers. Figure 6, (A) shows that a maximum of 51% of respondents expressed that their water pipelines were installed less than 10 years ago which was also a cause of the foul smell and unpleasant taste. Segment (B) shows a maximum of 35% of domestic units contain contaminants such as sediments in their tap water source, 18% of units had calcium, and 18% units had iron while the rest of the 28% of residential units were facing the problem of sulfur odor; (C) shows that a maximum of 81% of respondents of residential units consider that industrial sewage is a cause of water pollution in their area. Industrial sewage is composed of sodium, iron; methanol, chloride, and other toxic compounds which may be mixed with tap water supply pipelines and create health hazards such as cancer and respiratory diseases for commercial and domestic consumers. Segment (D) shows that 40% of respondents in the living communities had used aqua tabs i.e. chlorinated tabs, for cleaning water storage tanks to purify water from the effects of harmful compounds.

5. Statistical Tests for Data Analysis

The statistical analysis includes the ANOVA test, Correlation, and Reliability tests that were used to measure the association of variables for the accuracy of the data.

5.1. The one-way analysis of variance (ANOVA) Test

The one-way ANOVA is a statistical method that was used to estimate the significant variance between the means of two or more independent variables. It was used to assess the difference in the means of the dependent variables associated with the effect of the controlled independent variable.

5.1.1. The age of the respondents and sewage water near houses

The ANOVA test was performed to compare the effect of age on sewage water near houses in the contamination of water supply. The output of the ANOVA analysis shows that there was a statistically significant effect of age on sewage water near houses at the $p < 0.5$ level for the three conditions [F(4, 115) = .880, p = 0.478]. Therefore, the null hypothesis of no difference between the means was rejected. These findings show that the age group of the respondents will determine the sewage water near their house. The growing age of the respondents will enhance their understanding of the severe effects of sewage water near their houses. Sewage water may mix with groundwater supply which contains bacteria, parasites, and viruses that may cause health effects such as typhoid, and cholera.

5.1.2. The employment status and sewage water near their house

The ANOVA test was performed to compare the effect of employment status on sewage water near houses in the contamination of water supply. The output of the ANOVA analysis shows that there was a statistically significant effect of employment on sewage water near houses at the $p < 0.5$ level for the three conditions [F(4, 115) = 1.355, p = 0.245]. Therefore, the null hypothesis of no difference between the means was rejected. These findings show that the employment status of the respondents will determine the sewage water near their house. Employed respondents will take steps to eradicate sewage water flow near their livings to save themselves from the effects of contaminated water.

5.1.3. The age of the respondents and installation of water pipelines

The ANOVA test was accomplished to compare the effect of age on the installation of water pipelines in the contamination of water supply. The output of the ANOVA analysis shows that there was a statistically significant effect of age on the installation of water pipelines at the $p < 0.5$ level for the three conditions [F(4, 115) = 1.093, p = 0.365]. Therefore, the null hypothesis of no difference between the means was rejected. These findings show that the age group of the respondents will determine the installation of water pipelines as they have enough understanding that water pipelines should be replaced after a certain period because they may be contaminated due to poor water quality.

5.2. Correlation Analysis

In this study, a spearman's rank correlation coefficient was conducted to analyse and test the strength of a relationship between education status and sewage water near the house as shown in table 2. There was a significant relationship between Education Status and Sewage water near the house at the p = .347 significant levels at respondents rate (r) of 120 which depict that educated community observe that sewage water near houses may have health effects on humans.

Table 2 - Correlation Analysis

Variables	Correlation	Education Status	Sewage water near house
Education Status	Pearson Correlation	1	**.347****
	Sig. (2-tailed)		.000
	N	120	120
Sewage water near house	Pearson Correlation	**.347****	1
	Sig. (2-tailed)	.000	
	N	120	120

**. Correlation is significant at the 0.01 level (2-tailed). (Source: SPSS)

5.3. Reliability Statistics

In this study, the internal consistency of the constructs (research variables) was analysed by reliability test. A construct is reliable if the Alpha (α) value is greater than .70 (Hair et al., 2013). If the items are less than <10, then the value should be greater than >0.5. The construct reliability was evaluated by using Cronbach's Alpha. The output shows that demographic scale with 5 items (α = .394) and the contaminated water scale with 6 items (α = .551) was found reliable. Therefore, we can conclude that there was the reliability of the measures between demographics and contaminated water variables. The reliability results were summarized in table 3.

Table-3 Reliability Statistics

Research Variables	No. of Items	Alpha (α)
Demographics	5	.394
Contaminated water variables	6	.551

6. The Punjab Environmental Quality Standards (PEQS) for Drinking Water

In Pakistan, the Environmental Protection Department (EPD), Punjab has designed the drinking water quality standards as shown in table 4. The permissible limit of water quality above these parameters is illegal and may face a penalty for the proponent. Therefore, EPD has designed the permissible limit for the good quality parameter of water for its consumption that is enforced and implemented in Punjab, Pakistan.

Table-4Punjab Environmental Quality Standards for Drinking Water

Sr. No.	Parameters	Standard Values	WHO Standards	Remarks
1	Colour	≤15 TCU	≤15 TCU	WHO standards for Asian states
2	Taste	Acceptable	Acceptable	
3	Turbidity	<5 NTU	<5 NTU	
4	Total hardness as $CaCO_3$	<500 mg/l	---	
5	TDS	<1000	<1000	
6	pH	6.5-8.5	6.5-8.5	
	Essential Inorganic	**mg/l**	**mg/l**	
7	Aluminium (Al) mg/l	≤0.2	0.2	
8	Arsenic (As)	≤0.05 (P)	0.01	Same for Pakistan & Asian states
9	Barium (Ba)	0.7	0.7	
10	Boron (B)	0.3	0.3	
11	Cadmium (Cd)	0.01	0.003	
12	Chromium (Cr)	≤0.05	0.05	
13	Copper (Cu)	2	2	
	Toxic Inorganic	**mg/l**	**mg/l**	
14	Cyanide (CN)	≤0.05	0.07	Same for Pakistan & Asian states
15	Fluoride (F)*	≤1.5	1.5	
16	Lead (Pb)	≤0.05	0.01	Same for Pakistan & Asian states
17	Mercury (Hg)	≤0.001	0.001	
18	Nickel (Ni)	≤0.02	0.02	
19	Nitrate (NO_3)*	≤50	50	
20	Zinc (Zn)	5.0	3	Same for Pakistan & Asian states

*Indicates priority health related inorganic constituents, which needs regular monitoring. (Data Source: Environmental Protection Department, Punjab).

7. Health effects of contaminated water supply

The inadequate water supply is an inhibitor to the provision of good sanitation and hygiene. The effects of contaminated water in the area of Shadman colony, and the Gulshan-e-Rehmat colony of Gujrat, Pakistan were very severe. The condition of water supply pipelines and water storage tanks was very poor. The sewage pipelines were badly damaged and the sewage water flows near the housing societies. The underground water supply pipelines were damaged; therefore, the sewage water was getting mixed with it and supplied to the society. After using such water, people face gastrointestinal diseases, acute infectious diarrhoea, and Hepatitis C. The poor quality of water by the contaminated water supplies may lead to various diseases which are harmful to the human health as shown in table 5.

Table - 5 Diseases by the contaminated water

Sr. No.	Classification	Explanation	Associated diseases
1	Water borne	By drinking contaminated water	Cholera, Hepatitis, Typhoid
2	Water washed	Lack of water for proper hygiene	Scabies, Trachoma
3	Water based	By the swimming in contaminated water	Schistosomiasis, Guinea worm, Threadworm
4	Insect vector diseases	Bite by the infected insects that nourish in contaminated water	Malaria, Dengue fever, Yellow fever

The excessive accumulation of sediments and other microbial activity in the water supply pipeline was because of their long duration of installation and therefore it cause water pollution. It may also lead to an inadequate supply of water because of rusting, and accumulation of contaminants in water pipelines. The effects of water are mostly due to the non-use of water treatment methods and cleanliness issues of water supply pipelines. The improved quality parameters of water and its excessive quantity to meet the demands of societies are important for public health whereas the poor quality of water supply may lead to contaminated water which is a common health concern across the globe. It may lead to various illnesses which are a major concern of middle-income or developing states across the world. Each year, diarrhoea causes over 1.5 million infants and children to die because of a lack of safe drinking water (Malik, Q. A., and Khan, M. S., 2016). Diarrhoea kills about 11% of children under the age of 5 years across the globe which is greater than malaria, measles, and AIDS (Liu, L. et al., 2012).

8. Treatment techniques for contaminated water

The problem of poor water supply may lead to scarcity of water which can be improved by the alternation of underground water supplies, and contaminated water which can be treated by adopting low-cost water treatment technologies which are the very basic necessity of water purification that is needed to implement for developing nations on primary levels.

8.1. Aeration

The aeration processes are intended to remove gases and volatile substances by air stripping. The transfer of oxygen (O2) may be achieved without the need for any equipment by employing a simple cascade or diffusion of air into the water (Ternes et al., 2002; Westerhoff et al., 2005).

8.2. Chemical coagulation

The most common technique for treating surface waters is chemical coagulation-based treatment, which is entirely dependent on process units. Under properly controlled circumstances, chemical coagulants that are generally salts of aluminium or iron; are dosed with raw water to produce a solid flocculent metal hydroxide. For the elimination of several heavy metals and organic chemicals such as pesticides; the process of coagulation is very effective (Ternes et al., 2002; Westerhoff et al., 2005).

8.3. Chlorination

The chlorination process is one of the most frequently used disinfection processes because it has a significant oxidizing potential, inexpensive, simple to use, and effectively enhances the quality of drinking water. Furthermore, it also limits microbiological recontamination throughout the distribution system owed to the remaining chloride (Adams et al., 2002; Ternes et al., 2002; Pinkston and Sedlak 2004; Huber et al., 2005).

8.4. Activated carbon adsorption

The regulated thermalization of carbonaceous material, typically wood, coal, coconut shells, or peat; leads to the formation of activated carbon. It is usually used either in powdered or granular form. Pesticides and other organic pollutants are eliminated by using activated carbon (Ternes et al., 2002; Yoon et al., 2003; Snyder et al., 2006).

8.5. Ion exchange process

In between the water phase and solid phase, ions are exchanged. For the removal of heavy metals, the cation exchange process is used. The process of anion exchange can be utilized for the elimination of contaminants such as nitrite, which might be exchanged for chloride (Ternes et al., 2002; Westerhoff et al., 2005).

8.6. Membrane processes

Reverse osmosis, ultrafiltration, microfiltration, and Nano-filtration are the membrane processes that are most important in the treatment of water. Traditionally, these procedures have been used to create water for industrial or medical purposes, but now; they are being used to treat drinking water (Boyd et al., 2003; Snyder et al., 2006).

8.7. High-pressure processes

If a semi-permeable membrane (i.e., a membrane that admits the flow of the solvent but not of the solute) separates the two solutions, the solvent will naturally go from the lower-concentration solution to the higher-concentration solution. This procedure is known as the osmosis process. It is possible to force the solvent to flow in the opposite direction, from the higher to the lower concentration, by increasing the pressure on the higher concentration solution. The process is known as reverse osmosis, and the necessary pressure differential is called the osmotic pressure (Antony, A. et al., 2011).

8.8. Nano filtration process

The membrane used in Nano-filtration typically has pores that are between 0.001 to 0.01 nm in size, similar to reverse osmosis and ultrafiltration membranes. For the elimination of colour and organic compounds; the most effective method is Nano-filtration (Mohammad, A. et al., 2015).

8.9. Low pressure processes

Although the processes of ultrafiltration and reverse osmosis are equivalent, ultrafiltration uses membranes with substantially larger pore sizes (usually 0.002 to 0.03nm) and low pressures (Dasari, M. et al., 2005).

8.10. Microfiltration process

A direct extension of standard filtering into the sub-micrometre range is microfiltration. Pore diameters of microfiltration membranes typically range from 0.01 to 12 mm. It has been used to treat water to remove and dissolve organic carbon in association with coagulation (Lee, J. et al., 2000).

9. Conclusion

The overall study concluded that whenever sewage and septic systems are inappropriately installed, they can be direct sources of contamination of water supplies. As the waste material seeps out of these damaged pipes, they end up in groundwater nearby, where they contaminate it with bacteria and other toxic compounds rapidly. These direct causes of the contamination may be unintentional and cause trouble. It can be prohibited by better attention to detail, more thorough assessments, and regular maintenance. Wastewater treatment technologies can be used for domestic and commercial water purification. In Pakistan; Water and Sanitation Authority (WASA), Pakistan Environmental Protection Agency (PEPA), and Municipal Corporation (MC) can collectively contribute to minimizing the impacts of water supply contamination by repairing underground damaged water supply pipelines and involving public participation in decision making and design a mechanism of awareness about wastewater treatment methods. Government should take strict actions against such industrial units which are responsible for effluent removal, adopt no wastewater treatment method, and exceed the permissible limit of wastewater according to the prescribed guidelines of PEPA, and EPD.

10. Recommendations

There are some recommendations to save domestic units from water supply contamination and its impact on the population;

1. The best filtration technique is Activated Carbon Filters (ACF) which can eliminate certain organic content that affects the taste and odor; it can remove metal particles, i.e. copper and lead.
2. Ion exchange units with activated alumina can eliminate minerals, i.e. calcium and magnesium.
3. Use boil water for drinking purposes.
4. The drinking water quality standards should be design according to the guidelines of the PEPA and EPD, Punjab.
5. Sewerage water pipelines are regularly checked and monitored and restricted to get mixed with water supply pipelines.
6. The local administration should design a proper legislative plan with the collaboration of the WASA to control water pollution and spread awareness.
7. The government of Pakistan should take strict actions against industries for their industrial effluent disposal if they violate the rules according to the NEQs under the PEPA 1997 act.

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