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Assessment of Physico-Chemical and Biological Quality of Drinking Water in the Vicinity of Palosi Drain Peshawar

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Abstract: Research study was conducted from February to May 2002 to evaluate the ground water quality in residential areas along the Palosi drain Peshawar. The focus of the study was to evaluate the drinking water quality and to assess the influence of wastewater in Palosi drain on ground water in its adjacent areas. Water sample were collected from selected shallow wells, deep wells as well as from wastewater in the drain. The water samples were analyzed for pH, EC, turbidity, Ca, Mg, DO, BOD (only wastewater) and total coliforms. To determine the level of purity in drinking water the results were compared with WHO standards for drinking water and to assess the level of pollution in drain water the results were compared with National Environmental Quality Standards (NEQS). The results indicated that average pH and EC of drinking water were 7.8 and 0.62 dSm^1, respectively. Drinking water had low turbidity and high dissolved oxygen. Only problem found in drinking water was coliform bacteria as it crossed the limit of WHO in some areas. Average concentrations of Ca and Mg (16.2 and 48.4 mg/l) were within the WHO limits. However, average number of bacteria found in drinking water was 2/100ml, which according to HMSO (1970) is satisfactory condition if not alarming. Wastewater had high turbidity, low DO and high BOD, which proved the presence of high amount of organic and other particulate matter. Wastewater also had large number of coliforms due high amount of domestic wastewater. On the basis o results it may be concluded that ground water in area was of generally good quality and wastewater in drain had apparently little or no effect on the shallow wells.

Key Words: Water Quality, Shallow Wells, Turbidity, Dissolved Oxygen, BOD, Coliform Bacteria

Introduction

People can survive days, weeks or months without food, but only about four days without water (Kendall, 1992). The importance of water in human life underscores the concern about its quality. The drinking water must be free from impurities and bacteria. The provision of drinking water that is not only safe but also pleasing in appearance, taste and odor is a matter of high priority (WHO, 1997). Drinking water comes from two sources i.e. surface water i.e. lakes, reservoirs etc. and from underground aquifers. Ground water is a reliable source of water supply. It is often unpolluted due to restricted movement of pollutants in soil profile (Lamb, 1985). However, shallow and permeable watertable aquifers are most susceptible to contamination (Moody, 1996).

Ground water contamination problems are either directly or indirectly related to human activity (Canter and Sabatini, 1995). Experts estimate that industrial and domestic wastewater introduces up to a million of different pollutants into natural waters (Forstner and Wittman, 1981). Thus the water polluted with municipal and industrial wastes poses a great threat to public health.

Major types of pollutants introduced by the wastewater are nutrients, synthetic chemicals, trace elements and pathogenic microbes. The sources of ground water contamination are agricultural activities, industrial operations, septic tanks, urban land use and underground storage tanks. Drinking water infected with pathogenic microbes may act as carrier of various diseases i.e. cholera, typhoid, hepatitis etc. Gruson (1981) reported that water can probably transmit 36 infectious diseases.

Introduction of pollutants into the natural water can happen in two ways: either directly (point source) or indirectly (non-point source) depending on the local conditions. Direct or point source pollution occurs when source of potential pollutants i.e. septic tanks, disposal sites etc, are close to the ground water. Non point source or indirect pollution occurs when already polluted water in the vicinity enters into the fresh water body by lateral movement. An example of this is the lateral intrusion of seawater in the coastal areas (Hammer, 1986).

Public water supply systems of the developed world have under gone sweeping changes in the past two decades. However, situation in under developed regions of the world is almost opposite. According to a report, 40% deaths in developing countries occur due to water related diseases and 500 million diarrheal episodes occur each year in children under five years in Asia, Africa and Latin America (WHO, 1997).

Pakistan, also a developing country, is blessed with abundant water resource. However, due to lack of proper management strategy for water resources, the country faces twin problems of quantity and quality. Only limited population has access to public water supply, not necessarily clean. While the rest of population is dependent upon direct withdrawal of water from both surface and ground sources, where available, for its daily needs. National drinking water standards do not exist in Pakistan (Ali, 2001). Although, the Government departments and municipal agencies with responsibility of supplying water claim to follow WHO guidelines but it is largely theoretical due to lack of good quality monitoring in the country (Chilton, 2000).

Peshawar is the largest city and capital of NWFP. Public water supply of the city depends on both surface waters (from Tirah hills) and ground waters. There are about 206 tubewells in the public sector abstracting ground water, stored in overhead tanks and then distributed in the Peshawar city (MCP, 1997). However, this is limited to certain parts of the city while the suburban areas around the city are without proper water supply and sanitation system.

The people in these areas draw water from shallow wells dug in their homes. In certain areas the natural drains (for example, Palosi drain) are used as open sewers to carry the wastewater. The banks of these drains are thickly populated. There is a danger of contamination from the wastewater to shallow water table in adjacent areas.

Present study was conducted in residential areas adjacent to Palosi drain, Peshawar, which carries industrial and municipal wastes. The study focused on evaluation of drinking water quality of the area. Drinking water from household shallow wells, deep wells and wastewater from Palosi drain was analyzed for pH, EC, turbidity, dissolved oxygen, biochemical oxygen demand and total coliforms.

Materials and Methods

Research Area: Research was conducted in the adjacent area of Palosi drain Peshawar, used for carriage of industrial and municipal effluents. Industrial effluents come from Jamrud Industrial Estate Peshawar while domestic wastewater comes from residential areas along the drain, thus making it difficult to locate a major discharge point for domestic wastes. In the upper portion of the drain residential areas dominate the landscape while in lower section agricultural land with small population is conspicuous. Drain does not have uniform width or slope and it meanders its way to discharge point at Dag Syphon, Budni Nullah. Due to its undulating bed the flow of wastewater is not smooth and it resides for longer periods thus creating foul odours, which become severe with rise in temperature.

Water Sampling and Analyses: A total of 20 water samples were taken from shallow wells, deep wells and drain. Thirteen (13) water samples were collected from shallow wells in Canal Town, Lalazar Colony and Palosi village along the drain. Three water samples were collected from deep wells in Canal Town, Agricultural University and Palosi. While four water samples were collected from the drain water at head, middle and tail sections. The following analyses were performed: pH, Electrical Conductivity, Turbidity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Total Coliforms. The World Health Organization's (WHO) drinking water standards and National Environmental Quality Standards (NEQS) for wastewater were used for comparison (Table 1and 2).

Table 1: Water Quality Standards

S. No.	Parameters	WHO's Drinking Water Standards*	Wastewater Standards
1	pH	6.5-8.5	--
2	EC	1 dS/m	--
3	DO	4 mg/l	3 mg/l**
4	BOD	--	80 mg/l***
5	Turbidity	5 NTU	50 NTU**
6	Ca	50 mg/l	--
7	Mg	50 mg/l	--
8	Coliforms	0MPN/100 ml	10MillionsPN/100 ml*

*WHO (1997); **USEPA (1991); ***NEQS (1993);

pH: To determine the pH of water samples pH meter was used. First it was standardized with buffer solutions of known pH (4, 7 and 9) then probe was directly dipped into the water sample to record the pH value.

Table 2: Standard of Bacterial Quality for Drinking Water

Coliform Count/100 ml	Class	Quality
0	I	Excellent
1-3	II	Satisfactory
4-10	III	Suspicious
>10	IV	Unsatisfactory

Source: HMSO (1970)

Electrical Conductivity (EC): EC was measured by using a conductivity meter, which measures the current passing through a solution between two electrodes in the probe. The EC meter was calibrated by using standard solution at 25°C room temperature before taking the EC readings of water samples.

Turbidity: It is a unit of measurement that quantifies the degree to which light traveling through water column is scattered by the suspended organic and inorganic particles. The scattering of light has direct relation with suspended load. Insoluble particles of soil organic microbes and other material impede the passage of light to water by scattering and absorbing the rays (Hammer, 1986). Turbidity is commonly measured in Nephelometric Turbidity Units (NTU). Turbidity was measured by using turbidity meter. The instrument was first standardized with solutions of known turbidities 9 and 10 NTU, then vial containing sample was placed in the slot and turbidity value was recorded by turbidity scale.

Dissolved Oxygen (DO): DO of selected water and wastewater samples was determined by Iodometric method, which is a most precise and reliable titremetric method (APHA, 1992). This method is based upon addition of divalent manganese sulphate followed by a strong alkali (Iodide azide). DO rapidly oxidizes in equivalent amount of MnOH to higher valency state. Addition of H_2SO_4 reverts the reactions with production of Iodine. Then sample is titrated against sodium thiosulphate in the presence of starch indicator and end point is appearance of clear water. DO was calculated by using following formula:

$$\text{DO (mg l}^{-1}\text{)} = \text{Initial burette reading-Final burette reading} \quad (1)$$

Calcium and Magnesium: Ca and Mg concentrations in drinking and wastewater samples were determined by atomic absorption spectrophotometer.

Biochemical Oxygen Demand (BOD): BOD is the quantity of oxygen utilized by a mixed population of microbes in the anaerobic oxidation of organic matter in a sample of water at temperature of 20°C (Hammer, 1986). The BOD procedure, which was used in monitoring of water quality and biodegradation of waste materials, is designed to determine how much oxygen microorganisms consume during oxidation of the organic matter in the sample.

BOD of three wastewater samples was determined by using incubation method (APHA, 1992). BOD was determined in the laboratory by determining zero day DO and by incubating the same water sample and measuring the amount of oxygen consumed during a five-day period. The Oxygen (DO) remaining after five days of incubation was determined chemically by using titremetric methods.

BOD was calculated by using following formula;

$$\text{BOD} = \frac{\text{0 day DO} - \text{5 day DO}}{\text{ml of sample used}} \times 300^{*} \quad (2)$$

*Dilution Factor= Volume of sterile water used

Microbial Analysis: Microbial analysis of the water was performed by determining the most probable number of coliform bacteria (indicator organisms) in 100ml of water sample. The standard of microbial purity for potable water is counted as total coliform/100ml of water sample (MacDonald and Kay, 1988). Coliform group is widely used as indicator organism of choice for drinking water (Droste, 1997). The coliform group includes E. Coli and some other types that originate from other sources as well as in human faecal discharge (Allen, 1978; USEPA, 1991). Coliform bacteria are small rod-like gram negative organisms that are capable of fermenting sugars (lactose) with the production of acids and gas in abundance. Because of their abundance in intestinal tract, it is assumed that water cannot be polluted without their presence. Hence their presence might be considered a prima facie for feacal pollution of water. Although, their presence may not provide us the information about the type of pathogens in water. But it indicates the health risk, which should be investigated before the supply is consumed (MacDonald and Kay, 1988). Six drinking and wastewater samples were analysed for the presence of coliforms by using Multiple Fermentation Tube Method (APHA, 1992).

Results and Discussion

pH: Fig. 1 shows the pH values of drinking water and wastewater at three locations in the research area. At the head section of Palosi drain, pH of drinking water was slightly alkaline while the pH of wastewater was slightly acidic. At the middle section pH of drinking water was slightly alkaline while the pH of wastewater was slightly acidic. At the tail section pH of both drinking and wastewater was slightly alkaline. The pH of wastewater at tail section was alkaline as compared to head and middle section. The reason could be dilution provided by surface drain water and canal water at the tail section of the Palosi drain. pH of drinking and wastewater has a strong effect on the dissolution of trace elements as they become more mobile in water system at strong acidic pH and vice versa.

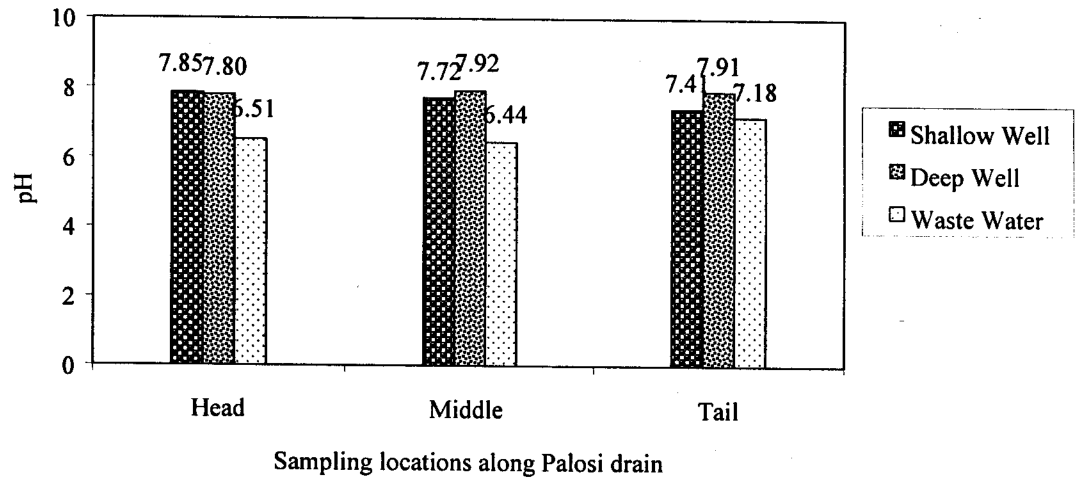

Fig. 1: pH of Drinking and Waste Water

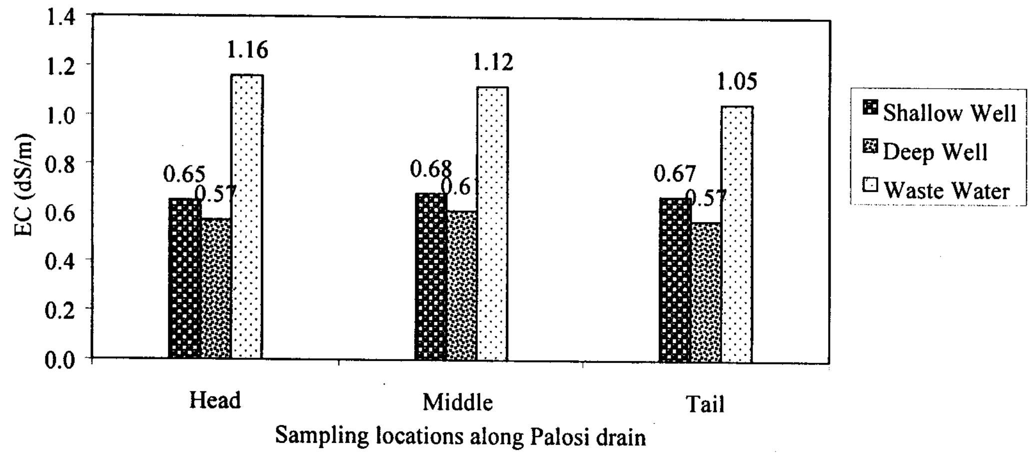

Fig. 2: EC of Drinking and Waste Water

Electrical Conductivity (EC): Fig. 2 shows the EC value of drinking and wastewater samples collected from research area. The EC values of drinking water at all the three locations were less than 0.7 dSm^{-1}, which means water has low concentration of salts. Therefore, the drinking water can be categorized as none-saline. However, the EC values for wastewater at all the three locations were in slightly saline categories (0.7- 2.0 dSm^{-1}).
The wastewater may not lead to build up of salts when used for irrigation, provided the risk of bacteria and toxic elements is eliminated. The maximum permissible limit of salinity is 3 dSm^{-1} (Ayers and Westcot, 1989). All the shallow and deep wells samples had EC value less than 1 dSm^{-1}. So it can be assumed that the salts present in the ground water are due to natural sources. There is no guideline value proposed for EC of drinking water by the WHO. However, excessive salts, such as Na and Mg, in drinking water may produce a laxative effect on the person consuming them.

Dissolved Oxygen (DO): Fig. 3 shows the DO content of the wastewater samples at three locations of the drain. At head section DO was zero, which is clear indication of heavy pollutant load in the drain water. It was also observed that at this section there was little dilution of wastewater and low aeration as wastewater was stagnant. At the middle section, situation improved and DO content reached to 8.1 mg/l. This high DO content may be attributed to aeration as water travels down stream and also mixing of surface drainage water with wastewater. At the tail section, DO content again dropped to low 3.1 mg/l. This value is less than the USEPA standard of 4 mg/l. This may be attributed to greater depth of mixing zone and virtually stagnant water at the tail section of the drain. Wastewater dilution depends upon natural self purification capacity, depth of river and season of the year (Hammer, 1986).
DO content of drain wastewater varies with large order of the magnitude owing to varying conditions in the surrounding. The average DO content of drain water was very low and gave an indication of pollution. The reason for this low DO content may be due to the presence of organic substances that are decomposed through bacterial action and oxygen is consumed in the process thus resulting in high oxygen demand.

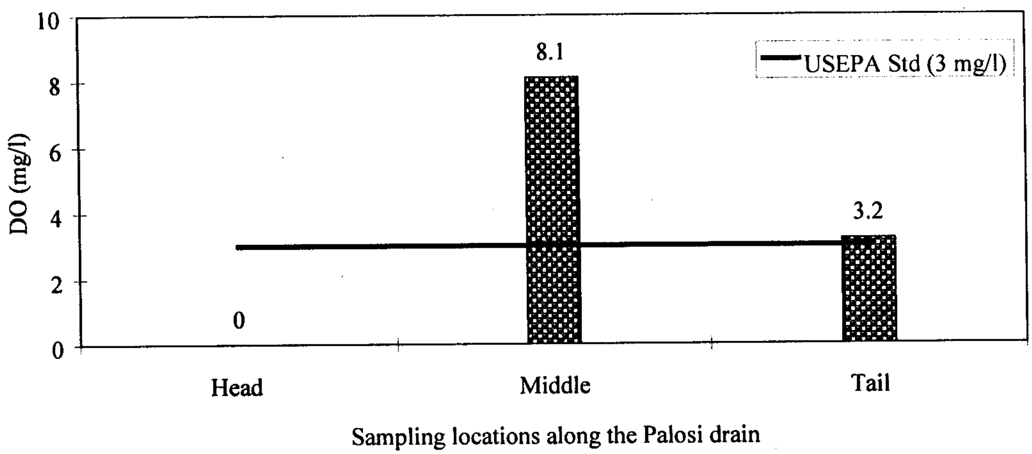

Fig. 3: Dissolved Oxygen of Wastewater

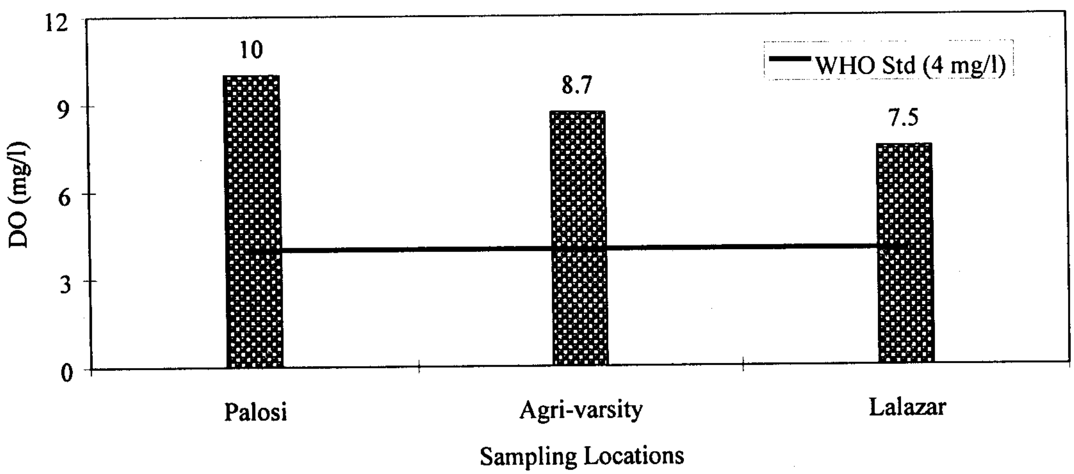

Fig. 4: Dissolved Oxygen of Drinking Water

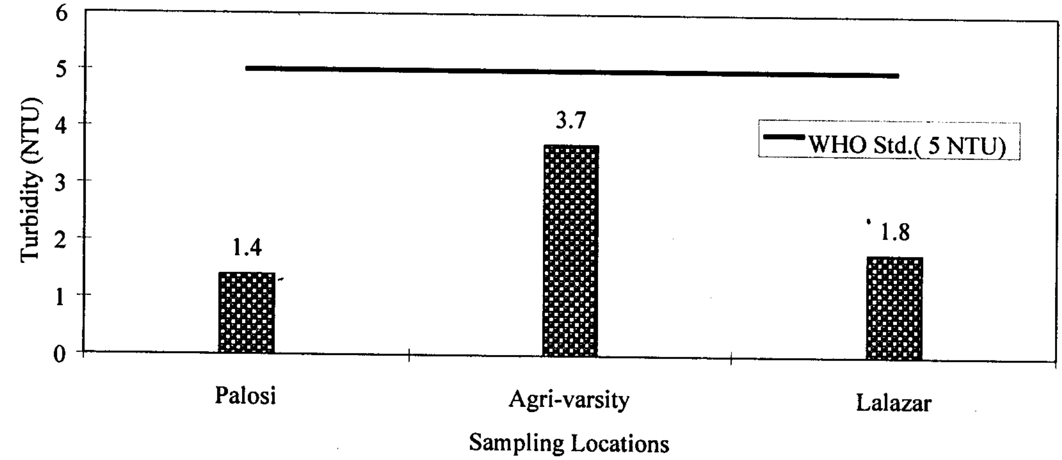

Fig. 5: Turbidity of Drinking Water

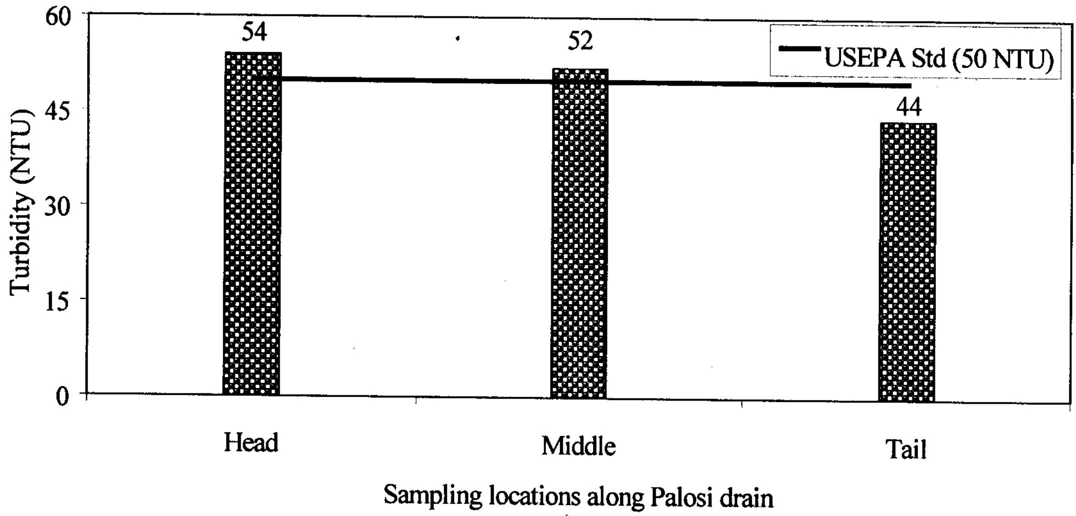

Fig. 6: Turbidity of Wastewater

Fig. 4 shows the DO content of drinking water samples randomly collected from research area. All the three water samples had high DO content and did not fall below the limit of 4 mg/l, which gives an indication that drinking water is free from oxygen consuming organic substances. The importance of DO content in drinking water is due to its influence on organoleptic properties. There are no health-based guidelines for DO. The depletion of DO in water supply can encourage microbial reduction of nitrate to nitrite and can increase concentrations of iron in the solution resulting from corrosion of metal pipes (Hammer, 1986).

Presence of DO content in water is dependent on several factor such as temperature, composition of water and biochemical processes within the distribution system. A DO content, substantially lower than saturation concentration may indicate occurrence of undesirable processes, which may adversely affect water quality.

Turbidity: Fig. 5 shows the turbidity of three drinking water samples, randomly collected, from the research site. It is evident from the Figure that the turbidity of the drinking water samples was lower than the WHO permissible limit of 5 NTU, which means water has lesser particulate matter and organic matter that create turbid conditions. Turbidity in drinking water may hinder disinfection process during treatment, therefore, giving rise to risk of water born diseases.

Fig. 6 shows the turbidity of wastewater at three different locations of drain. Turbidity was 52, 54 and 44 NTU at head, middle and tail sections of the drain, respectively. The results clearly indicate that there is a heavy amount of substances in the wastewater that create turbid conditions. The drop of turbidity value to 44 NTU at the tail section of drain could be attributed to dilution provided by drain water and stillness of water which allows the suspended solids to settle down there by reducing the turbidity of water. The turbidity of wastewater was higher than the EPA standard of 50 NTU. The turbidity of water should be below the permissible limit to support aquatic life and to protect recreational value of streams, lakes and rivers.

Calcium (Ca) and Magnesium (Mg): Fig. 7 and 8 show Ca and Mg concentrations, respectively, in drinking and waste water at three locations in research area. The concentrations of both Ca and Mg in drinking and waste water at head section was accord with WHO and NEQ standards.

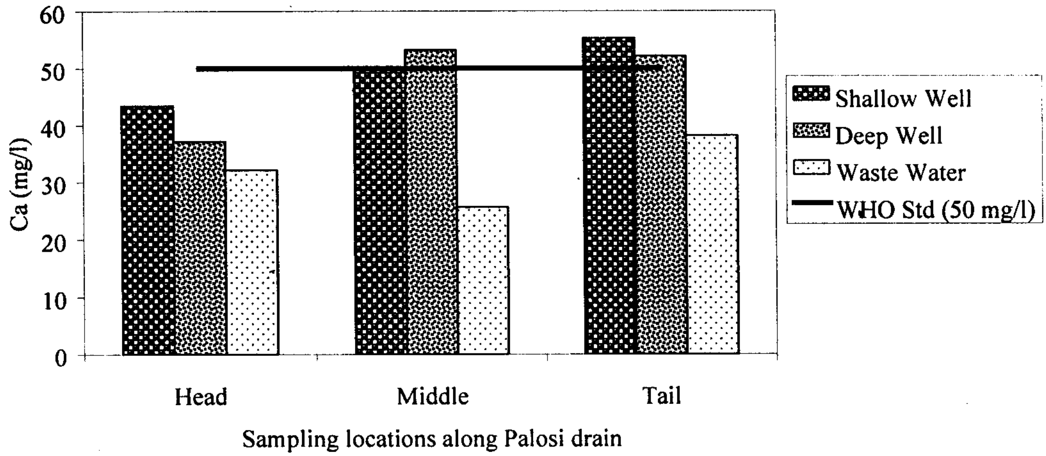

Fig. 7: Ca Concentration in Drinking and Waste Water

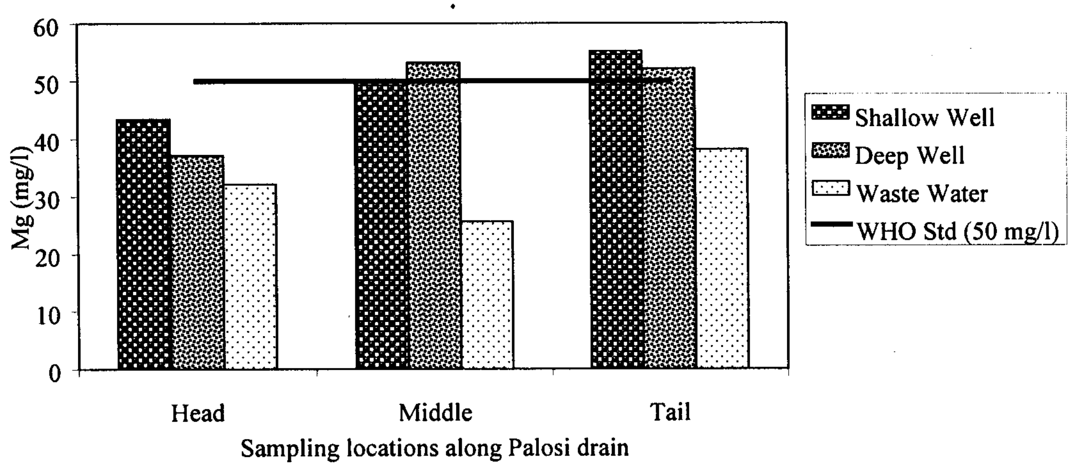

Fig. 8: Mg Concentration in Drinking and Waste Water

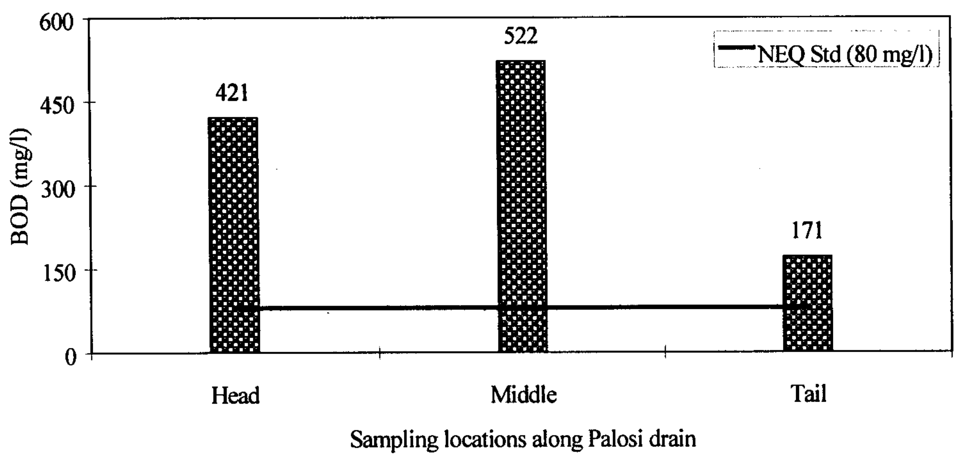

Fig. 9: Biochemical Oxygen Demand (BOD) of Wastewater

However, they were slightly higher in drinking water than the WHO standards at middle and tail sections. Comparison of drinking and waste water values shows that drinking water has more Ca and Mg concentrations than the waste water at all the three locations. The reason of high Ca content in drinking water could be due to the influence of parent material (i.e. Lime Stone) of the area.

Biochemical Oxygen Demand (BOD): Fig. 9: shows the BOD of wastewater at three different locations in drain. At the head section BOD was 421 mg/l, which is significantly higher than the 80 mg/l limit of NEQS. At the middle section, BOD reached highest value of 522 mg/l. This high BOD is a clear indication of heavy pollution in the drain. These higher BOD values also show that wastewater contain high amount of oxygen demanding organic substances. However, at the tail section of the drain BOD dropped significantly as compared to head and middle sections but was still higher than the wastewater standard. The reason could be dilution with the surface drainage water and aeration. The average BOD (371 mg/l) of wastewater in the drain indicates high organic matter and little dilution/re-oxygenation.

Microbial Analysis: Fig.10 shows the Most Probable Number (MPN) of coliform bacteria in 100 ml of drinking water. The results show that 2 out of 3 samples contained bacteria above the WHO prescribed limit of zero MPN/100ml. This means that water was contaminated with either feacal pollution, which could be due to leaking septic tanks or broken supply pipes. Fig. 11 shows the most probable number of bacteria in 100 ml of wastewater. The results indicate that wastewater contained very large number (average 6.8 million) of bacteria owing to high amount of raw sewage in the drain. In raw sewage concentration of total coliform can range from 10 to 100 million coliforms /100 ml (Pearce *et al.,* 1998). The large number of bacteria present in wastewater not only pose a health hazards to the person who uses it for irrigation but also there is risk of contaminating food products. Average number of bacteria in drinking water was two, which according to HMSO (1970) criteria of microbial purity is satisfactory (Table 1).

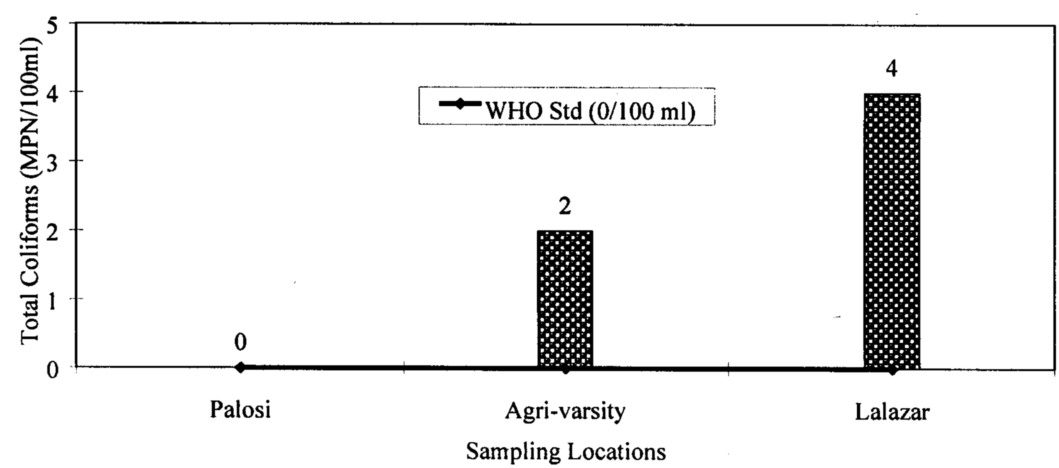

Fig. 10: Total Coliforms in Drinking Water

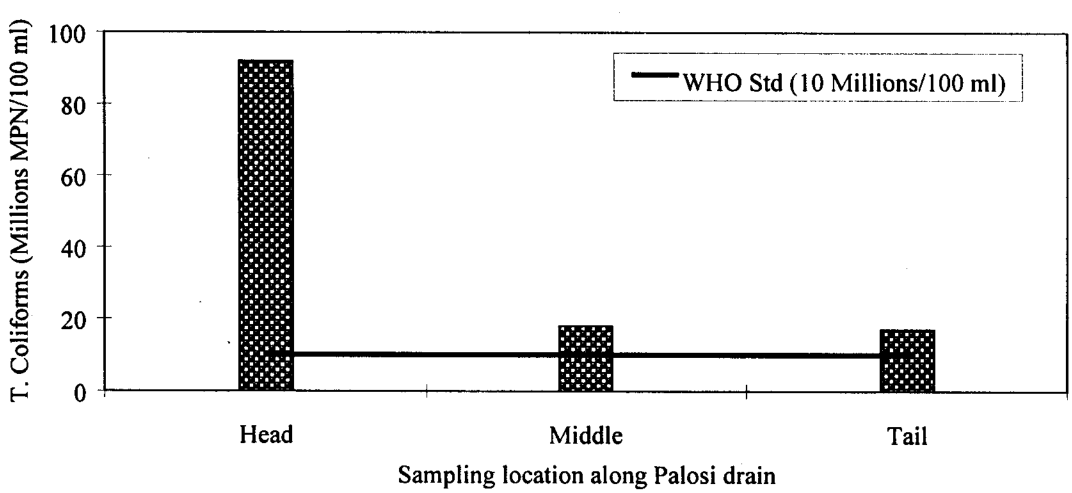

Fig. 11: Total Coliforms in Wastewater

Conclusion

It is evident from the results that drinking water was slightly alkaline but free from salinity as its average pH and EC were 7.8 and 0.62 dSm^{-1}, respectively. Average DO and turbidity of drinking water were 8.7 mg/l and 1.94 NTU, respectively. The high DO and low turbidity showed that water was free from organic pollutants. Average DO and turbidity of wastewater were 3.7 mg/l and 50 NTU, respectively. The low DO and high turbidity confirm the presence of high amounts organic wastes in wastewater. Average concentrations of Ca and Mg (16.2 and 48.4 mg/l) were within the WHO limits. Average Biochemical oxygen demand of wastewater was very high (BOD of 371 mg/l) due to presence of high amount pf industrial and municipal wastes in wastewater. Drinking was polluted in some areas as it had average number of Coliform which exceeded from the WHO's drinking water standards.

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