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Study of Trace Elements in Drinking Water in the Vicinity of Palosi Drain, Peshawar

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Abstract: Research study was conducted from January to May, 2002 in residential areas along the Palosi Drain, Peshawar. Main objective of the study was to evaluate water quality of shallow and deep wells in the vicinity of Palosi Drain. For this purpose, 20 water samples were taken 13 from shallow wells, 3 from deep wells and 4 from wastewater in the Palosi Drain. Water samples were analyzed for heavy metals or trace elements (Cd, Pb, Ni, Cu, Fe, Zn, Mn). The results indicated that heavy metals such as Cd, Ni and Pb caused problem at some locations due to their elevated concentrations (0.04, 0.38 and 0.29 mg l^{-1}, respectively) as compared to WHO's drinking water standards. The reason could be the corrosion of plumbing fixture and piping fixtures. However, other trace elements such as Cu, Fe, Zn and Mn were not a problem as their average concentrations (0.20, 0.30, 0.40 and 0.16 mg l^{-1}, respectively) were within the WHO's drinking water standards. It may be concluded that drinking water was generally of good quality and wastewater did not affect the water quality of shallow wells.

Key words: drinking water, trace elements, heavy metals, shallow wells, waste water

Introduction

Water in natural conditions may contain impurities because it dissolves the substances while moving downward as part of hydrological cycle. The principal natural chemicals found in ground water are dissolved salts, Iron, Manganese, Fluoride and other trace elements. However, this problem gets accentuated when human activity over stretches the environments' limits of endurance. Ground water contamination is often result of human activities (Hammer, 1986).

Major types of pollutants introduced by the wastewater are nutrients synthetic chemicals and pathogenic microbes. The sources of ground water pollution are infiltration of wastewater; leachate from solid landfill; improperly constructed disposal sites and agricultural chemicals. Varshney (1983) stated that groundwater pollution can be caused by three major sources: (I) weathering of soil and rock minerals (ii) decomposition of organic material and (iii) industrial effluents, sewage and municipal wastewater. Although ground water pollution can happen from the said sources however, Burkart *et al.* (1999) reported that occurrence of trace elements in groundwater were directly related to soil characteristics that determine the rate of water movement. In general shallow, permeable water table aquifers are the most susceptible to contamination (Moody, 1996). The dilemma of ground water pollution is that it is not easily detectable. Almost every instance of ground water pollution has been discovered only after a drinking water supply was affected .

Ground water pollution can occur either by directly (point source) or indirect (non point sources) depending on the local condition. Direct or point source pollution occurs when source of potential pollutants i.e. septic tanks, disposal sites etc, are close to the ground water. The leakage from these sources can directly pollute the ground water. While indirectly it can be polluted by lateral movement of water underground i.e. seawater intrusion in coastal areas (Hammer, 1986).

Peshawar is the largest city and capital of NWFP. Public water supply of the city depends on both surface water (from Tirah hills) and ground water. There are about 206 tube wells in the public sector abstracting ground water, stored in overhead tanks and then distributed in the Peshawar city (MCP, 1997). The people in these areas draw water from shallow wells dug in their homes. In certain areas the natural drains (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. Khan (2001) reported that groundwater in areas near to source of effluent discharge was contaminated as compared to areas away from the source. Kaushik (2000) found the groundwater quality to be significantly higher in those sites in Haryana, India where there was a large amount of solid waste dumping. Mikula (1996) concluded that pollution of groundwater in selected allotment gardens in Poland had some tendency to decrease with increasing distance from the petrochemical work. Singh *et al.* (1996) found that both hand pumps and boreholes near urban industrial units in Uttar Pradesh had poor water quality. Lenz *et al.* (1998) reported that some non-degradable organic compounds in groundwater at three locations in Germany were higher

than drinking water quality standards.

Present study was conducted in residential areas adjacent to Palosi drain, Peshawar, which carries industrial and municipal wastes. The study focussed on detection of trace elements in drinking water of the area. Drinking water from household shallow wells, deep wells and wastewater from Palosi drain was analyzed for heavy metals or trace elements (Cd, Pb, Ni, Cu, Fe, Zn, Mn). These results were compared with WHO's standards for drinking water and National Environmental Quality Standards (NEQS) for wastewater to make qualitative inferences while in Pakistan drinking water quality standards do not exist (Ali, 2001).

Materials and Methods

The present investigation was conducted at the adjacent area of Palosi drain, 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. The industries that are prominent in the Industrial Estate are: match, marble, edible oil, plastic and pharmaceutical industries. In the upper portion of the drain residential areas dominate the landscape while in lower reaches agricultural land with small population is conspicuous. The drain does not have uniform width or slope and it meanders its way to discharge point at Dag Syphon at 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 trace elements were analyzed: Cd, Pb, Ni, Cu, Fe, Zn, and Mn. The World Health Organization's (WHO) drinking water standards and National Environmental Quality Standards (NEQS, 1993) for wastewater were used for comparison

Determination of heavy metals or trace elements: Trace elements and heavy metals can be classified into two categories: (I) those metals (such as Cu, Fe, Mn, and Zn) which are essential to living organisms), however, excessive levels of these elements can be detrimental to living organisms; (ii) non essential elements (i.e. Pb, Cd and Ni) are of particular concern in drinking water (Kennish, 1992) These metals once introduced into the water system can be transported by overland flow and by flow through the unsaturated and saturated zones in the soil. Metal concentrations in water can be detected by Atomic Absorption Spectrophotometer (APHA, 1992). The atomic absorption method enables metallic elements to be determined with remarkable sensitivity and accuracy (Kopp, 1977).

Results and Discussion

Cadmium (Cd): Fig. 1 shows that Cd concentration in drinking water at the head section (Canal Town) was higher than the WHO's permissible limit of 0.003 mg l^{-1} however, its concentration in wastewater was in accordance with NEQS' permissible limit of 0.1 mg l^{-1}. The Cd concentration in both drinking and wastewater at the middle section (Lalazar) were in accordance with WHO's and NEQ standards for drinking water and wastewater, respectively. At the tail section (Palosi) Cd concentrations in both drinking and wastewater was not detectable.

The results clearly indicated that Cd is a problem in the residential areas near drain's upper reach (Canal Town) while in the lower reaches (Lalazar and Palosi) Cd is not a problem because either it was in low amounts or zero both in drinking and wastewater. Cadmium in wastewater is dependent upon discharge variation and patterns of effluent emission (Forstner and Wittman, 1981). Therefore, it may be concluded that high Cd concentrations in wells of canal town is a localized problem, which may be due to pumping and plumbing system. Bakraji and Karajo (1999) found out that Cadmium got into a ground water from corrosion of galvanized pipes and fittings.

Lead (Pb): Fig. 2 shows the Lead concentration in wastewater at the head section (Canal Town) of the drain was 0.004 mg l^{-1} while the drinking water from the surrounding area had higher Lead concentration than the permissible limits of WHO. At the middle section (Lalazar) Lead in wastewater was in accordance with NEQS standards. However, drinking water from the surrounding areas had higher concentration than the WHO standards. At the tail section (Palosi) wastewater had zero concentration while drinking water contained higher concentration of Lead than the permissible limit.

The Lead concentration in drinking water in areas near to the Canal Town and Palosi could be due to local factors (i.e. plumbing materials) as wastewater did not contain Lead. Bakraji and Karajo, (1999) stated that Lead is commonly used in plumbing materials. Natural water

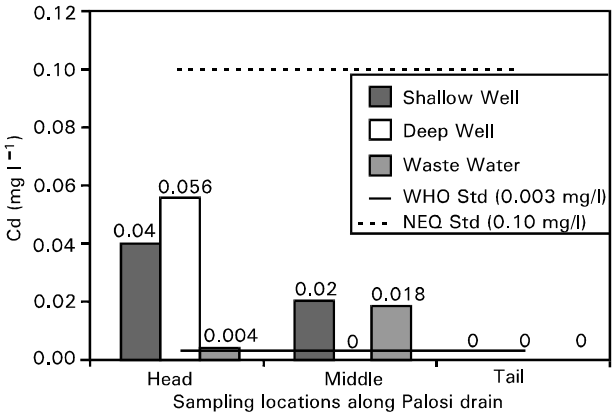

Fig. 1. Cd concentration in drinking and wastewater

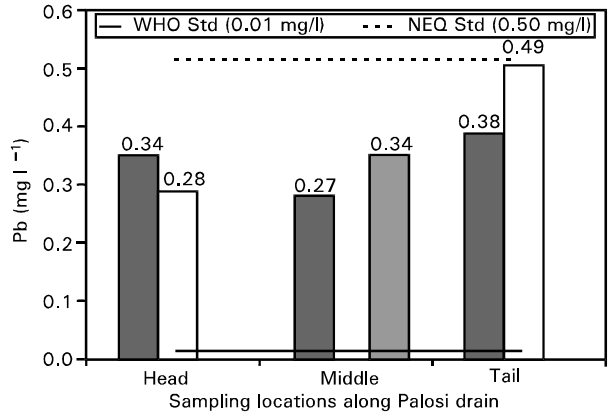

Fig. 2. Pb concentration in drinking and wastewater

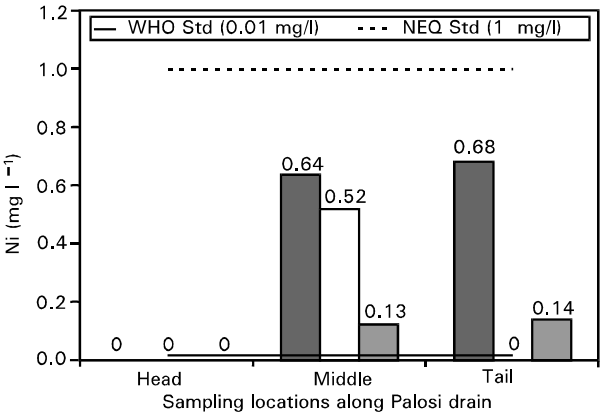

Fig. 3. Ni concentration in drinking and wastewater

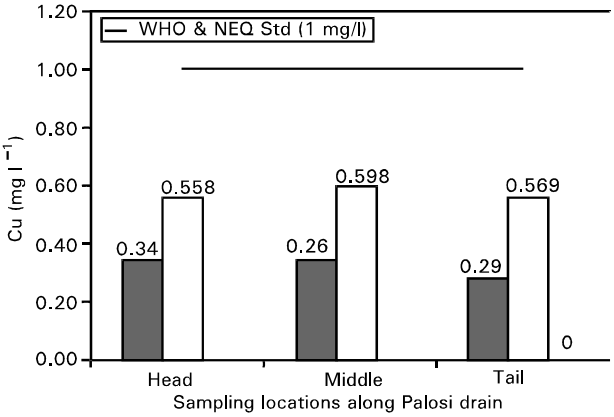

Fig. 4. Cu concentration in drinking and wastewater

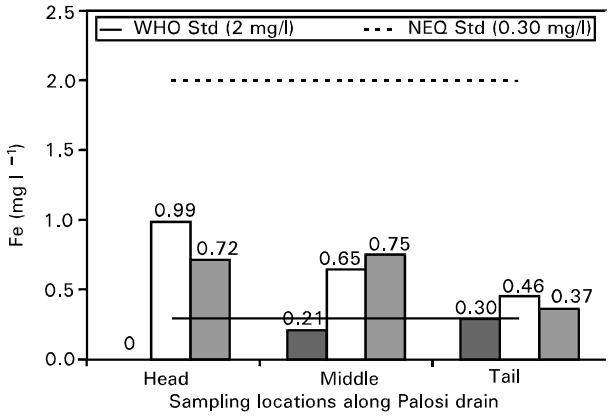

Fig. 5. Fe concentration in drinking and wastewater

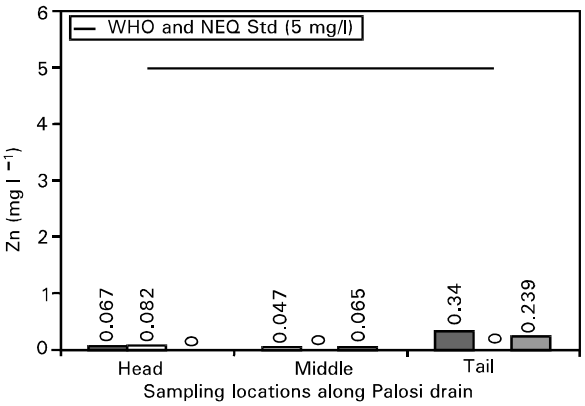

Fig. 6. Zn concentration in drinking and wastewater

usually contains very little Lead. Concentrations occur in water distribution system or in the pipes of a home or facility (Kendell, 1992). Lead concentration in drinking water can be enhanced from dissolution of pipes especially if water is low in calcium concentration (Forstner and Wittman, 1981).

Nickle (Ni): Fig. 3 shows that at the head section of the Palosi drain and its surrounding residential areas (Canal Town and Lalazar colony) Ni concentration both in drinking and wastewater was zero. At the middle section of the drain and its surrounding residential areas (Lalazar) Ni concentration both in drinking and wastewater was

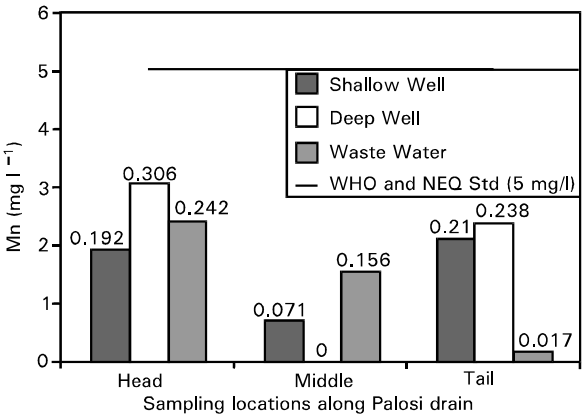

Fig. 7. Mn concentration in drinking and wastewater

higher than the permissible standards of WHO and NEQS, respectively. However, drinking water from deep well contained more Ni as compared to wastewater which means Ni presence could be due to indigenous sources (i.e. parent material) rather than due to wastewater induced phenomena.

In Palosi area Ni concentration in both drinking water and wastewater was above from the permissible standards (WHO and NEQS). However, Ni concentration in deep well water was zero, which means Ni problem could be due to local conditions such as plumbing material. Pure nickel is used in plumbing fixture (James and Ramamoorthy, 1984).

Copper (Cu): Fig. 4 shows that Copper concentration both in drinking and wastewater at Canal Town, Lalazar and Palosi area was well within the acceptable limits of WHO and NEQS, respectively. The Copper concentration in drinking water samples ranged from 0.37 to 0.45 mg l^{-1} with an average of 0.43 mg l^{-1} which is well within the permissible limits of WHO. In a Canadian survey of distributed water supplies, the Copper concentrations ranged from 0.01 to 0.09 mg l^{-1} with a median of 0.27 mg l^{-1} for 27 supplies with acid or neutral pH (Health Canada, 1992). A number of studies in United States indicate that Copper level in drinking water samples can range from 0.005 to 18 mg l^{-1}, with the primary source, most of often, being the corrosion of interior Copper plumbing (ATSDR, 1990; USEPA, 1991).

The Copper in wastewater at all the three locations was either undetectable or it was not present in soluble form in water. This means that Copper could have precipitated in the sediment of the drain as the pH of wastewater was in slightly acidic category.

Iron (Fe): As evident from Fig. 5 that Iron concentration in both drinking and wastewater were well within the permissible limits of WHO and NEQS, respectively. The Iron was found in the range of 0 to 0.99 mg l^{-1} in drinking water samples with an average of 0.5 mg l^{-1} which is well within the permissible limits of WHO. The Fig. 5 also highlights the fact that Iron present in drinking water could be due to cast Iron pipes. Concentrations of Iron may be higher in countries where various Iron salts are used as coagulating agents in water treatment plants and where cast Iron, steel and galvanized Iron pipes are used for water distribution (WHO, 1997). Iron concentration in deep well was higher as compared to shallow wells. This could be attributed to the reducing conditions in deep wells. The Iron concentration in drain water was in the range of 0.37 to 0.75 mg l^{-1} with an average of 0.63 mg l^{-1} which is significantly lower than NEQ standard of 2 mg l^{-1}. The median Iron concentrations has been reported to be 7 mg l^{-1} in rivers (NRC, 1979).

The average value of 0.5 mg l^{-1} was found in drinking water sample which is significantly lower than the standards, however, there is a possibility that consumers may complain about color, developed in pipe systems, laundry stains and metallic taste of water at this concentrations.

Zinc (Zn): Fig. 6 shows Zinc concentration in both drinking water and wastewater. The Zinc concentration in both waters was in accordance with WHO and NEQS standards, respectively. Zinc concentrations in drinking water ranged from 0 to 3.6 mg l^{-1} with an average 0.13 mg l^{-1} which is lower than the WHO standard of 5 mg l^{-1}. Nriagu (1980) reported that Zinc concentration in ground water ranged from 10 to 40 micro gram / litre. However, in tap water Zinc concentration can be higher as a result of the leaching Zinc from piping and fittings. In a survey of public water supplies from 6000 wells in Finland, Zinc concentration in the range of 1.1 to 24 mg l^{-1} were reported. The low concentration of Zn in drinking water could be due to the fact that the pH of water samples was slightly alkaline and its solubility is a function of decreasing pH .

For Zinc no health based value was proposed by WHO because Zinc is essential nutrient and body requires it in higher amounts. The daily requirement for an adult human is 15 to 22 mg per day (WHO, 1997). In 1982 a joint FAO and WHO committee proposed a daily dietary Zinc requirement of 0.3 mg/kg of body weight and a provisional maximum tolerable intake of 1 mg/kg of body weight. However, it is possible that drinking water containing high amount of Zinc may develop an undesirable astringent taste.

Manganese (Mn): The Mn concentration in both drinking and wastewater were in accordance with the WHO and NEQ standards, respectively (Fig. 7). Mn concentration in drinking water ranged from 0 to 0.43 mg l^{-1} with an average of 0.13 mg l^{-1} which is significantly lower than the WHO permissible limit. Mn concentration in deep well was greater than the shallow well. This could be due to the reducing conditions in deep wells. Reducing conditions in ground water and some lakes and reservoirs are conducive to high level, up to 1.3 mg l^{-1} in neutral water (ECAO, 1984). Mn concentration in drain water ranged from 0.02 to 0.24 mg l^{-1} with an average of 0.14 mg l^{-1} which is well within the acceptable limits of NEQS. Mn concentration in lakes and rivers around the world ranged from 0.001 to about 0.6 mg l^{-1} (WHO, 1997). Manganese is an essential element for human, the adverse health effects can be caused by in adequate intake. By oral route Mn is regarded is one of the least toxic element. Suzuki (1970) in Japan reported that Mn concentration of 0.75 mg l^{-1} in the drinking water supply had no apparent adverse effects on consumers. WHO (1997) reported that the intake of Mn can be as high as 20 mg l^{-1} without apparent health effects. Provisional health guideline value of 0.5 mg l^{-1} should be adequate the protect public health.

The results clearly show that only trace element such as Nickel, Cadmium and Lead were problem in some areas because their average concentrations exceeded from the WHO's drinking water standards. While trace elements such as Iron, Copper, Zinc and Manganese had average concentrations within the permissible limit of WHO's drinking water standards. It can be concluded that drinking water in research area was generally of good quality and wastewater had apparently little or no effect on the quality of water in near by areas. Based on the results of the study it is proposed that proper maintenance of plumbing and pumping system should be done to avoid secondary contamination of drinking water. Pipes and other fixtures containing Cu, Cd, and Pb should be avoided. Finally, yet importantly, every effort was expended to get maximum possible information regarding water quality. However, due to the limitation imposed by time and paucity of material and technical resources certain aspects (effluent discharge, sediment load, contaminant source etc.) were excluded. Thus it is proposed that detailed research should be carried out to assess the severity of the problem.

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