

Long term effect of irrigation with the treated sewage effluent on some soil properties for date palms in Al Hassa, Saudi Arabia

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Abstract

There is a gradual decline in availability of fresh water to be used for irrigation in Saudi Arabia. As a consequence, the use of sewage and other industrial effluents for irrigating agricultural lands is on the rise particularly in developing areas. On the other hand, there is increasing concern regarding statutory and advisory food standards for trace metals throughout the world. Hence, a case study was undertaken to assess the long-term effect of sewage irrigation on some soil properties and heavy metals concentrations in the soils under the date palm in Al- Hassa; Saudi Arabia. To achieve this goal, thirty two surface soil samples were collected from the study area. Half were collected from an area irrigated for 13 years with treated sewage effluent. The rest of soil samples were collected from an area irrigated with well water in addition to reference samples from uncultivated areas. Sewage effluent, ground water, soil and plant samples were collected and analyzed mainly for metal contents. The results emphasized the role of sewage effluent irrigation on increasing heavy metal content as well as organic matter content in the soils when compared with the respective values obtained under well water irrigation. Furthermore, the soil salinity ranged from 2.5 to 3.69 dS/m with an average of 2.8 dS/m due to irrigation with well water. Soil salinity ranged from 3.58 to 20.7 dS/m with an average of 7.9 dS/m after irrigation for a long period with the treated sewage effluent. Sewage effluent contained much higher amounts of Zn, Cu, Fe, Mn, Co, Cr, Pb and Ni compared to ground well water. Generally soils receiving sewage irrigation for more than 13 years exhibited significant increases in Zn, Fe, Ni and Pb.

Key Words

Long-term sewage irrigation, heavy metals, soils, well water, date palm, sandy soil.

Introduction

In arid and semiarid regions such as Saudi Arabia, water demand has exceeded the reliable supply of surface water and renewable ground water due to rapid growth in municipal and industrial use. The agricultural sector is the major consumer of water in Saudi Arabia, using two-thirds of available resources. The growing competition for scarce water resources, coupled with laws limiting ground water pumping, has led to utilization of low quality water in irrigated agriculture in Saudi Arabia. However, applying effluent to arable lands also involves certain environmental and agricultural risks. Effluent differs from fresh water with higher contents of electrolytes, dissolved organic matter, suspended solids, and biochemical and chemical oxygen demand (BOD, COD). These varied constituents in effluent can affect soil physical and hydraulic properties. Although the concentration of heavy metals in sewage effluents are low, long-term use of these waste waters on agricultural lands often results in the build-up of elevated levels of these metals in soils (Rattan *et al.* 2002; Madyiwa *et al.* 2002; Yadar *et al.* 2002; Angin *et al.* 2004). On the other hand, crops raised on the metal-contaminated soils may accumulate metals in sufficient quantities to cause clinical problems both to animals and human beings consuming these metal rich plants (Miller, 1986). The objectives of this study were: (i) to study the chemical composition of sewage effluent and ground well water; (ii) to assess the effects of long-term irrigation with sewage effluent on metal contents in soils which are cultivated with date palm at Al Hassa area, Saudi Arabia.

Materials and methods

Study area and collection of samples

The study area is located between (N 24 ° 21' 325") and (E 46 ° 55' 906") where sewage effluent originating from Al- Hassa Sewage Treatment Plant have been used for irrigation purposes since 1995. Sewage effluent was collected periodically from the study area. Similarly, groundwater samples were also collected from wells used for irrigation in the study area. Thirty two surface soil samples (0–20 cm) were collected from sewage and adjacent well water-irrigated plots. Soil samples were dried, ground and passed through 2 mm sieve and kept for physical and chemical analysis.

Chemical analysis of sewage effluents, well water, soil and plant samples

An aliquot of 500 mL of sewage effluents and well water samples with 15 mL of HNO₃ was evaporated to near dryness on a hot plate. Then contents were digested with 15 mL of HNO₃ and 20 mL HClO₄ (70%) (Brar *et al.* 2000). The residue was taken up in 15 mL of 6N HCl and made to volume (50 mL) and contents were filtered. The filtrate was analyzed for P, K, S, Zn, Cu, Fe, Mn, Ni, Pb and Cd using inductively coupled plasma-atomic emission spectrophotometer (ICP-AES (Perkin-Elmer, Model 4300 DV)). Sewage effluent samples were analyzed for a pH and electrical conductivity using pH meter and salt-bridge, respectively. Carbonate and bicarbonates were estimated by titrating an aliquot of effluent samples with H₂SO₄. Soil pH was measured in suspension (soil paste) according to Datta *et al.* (1997). Organic carbon contents in soil were determined by the wet digestion method (Walkley and Black 1934; Nelson and Sommers 1982.). Further, 30 soil samples were selected and analyzed for texture by the hydrometer method (Day 1965; Gee and Bauder 1994). For heavy metal analysis, the soil samples were digested with HF; H₂SO₄ and HClO₄ according to Hossner (1997). The concentrations of metals were determined using an inductively coupled plasma-atomic emission spectrophotometer (ICP-AES). Plant samples were dried at 60 °C in hot air oven, ground and digested in an acid mixture of (HNO₃:HClO₄:9:4) (Jackson 1973). Metal contents in the plant digests were determined using an inductively coupled plasma-atomic emission spectrophotometer (ICP-AES). Due care was taken to avoid metal contamination in the process of sampling, drying, grinding, extracting and analysis. All equipment and containers were soaked in 10% NHO₃ for 24 h then rinsed thoroughly in de-ionized water before use. Also, quality control was assured by performing duplicate analyses on all samples and by using reagent blanks and standard reference soil (Till 1) which yielded As, Ni, Fe, Cu, Mn, Cd, Cr, Pb and Zn contents close to the certified values.

Results and discussion

The sewage effluents were found to contain much higher amount of Zn, Cu, Fe, Mn Co; Cr; Pb and Ni compared to the ground well water. Generally soils receiving sewage irrigation for more than 13 years exhibited significant increase in Zn, Fe, Ni and Pb. On the other hand sewage effluents were alkaline in reaction with pH values ranging from 7.5 to 8.5 (data not shown). The tolerance limit of pH for irrigation water ranged from 6.0 to 9.0 (Patel *et al.* 2004). Thus, pH of the effluent samples is within the permissible limit. Electrical conductivity of sewage effluents exceeded 1 dS/m (2.1–2.2 dS/m) indicating that these effluents were saline in nature. The carbonate and bicarbonate contents in effluent samples varied from traces to 1.1 and 1.5 to 3.9 meq L⁻¹, respectively. Carbonate concentrations in all the samples were much lower as compared to bicarbonate concentrations. The sand; silt and clay contents of soils receiving sewage effluent ranged from (70.3- 86.3), (5-14 %) and (7.7 – 15.7%), in the respectively. Soil pH varied from 7.6 to 8.1 and 7.9 to 8.7 in sewage and well water-irrigated soils, respectively. The organic matter content varied from 0.8 to 2.4% in sewage-irrigated soils, the corresponding values for well water-irrigated soils were 1.0–1.09 %. Soil salinity ranged from 2.5 to 3.69 dS/m with an average of 2.8 dS/m due to irrigation with well water. Soil salinity ranged from 3.58 to 20.7 dS/m with an average of 7.9 dS/m due to irrigation for a long period with the treated sewage effluent. The results emphasize the role of sewage effluent irrigation in increasing heavy metals contents in the soils when compared with values well water irrigated soils.

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