

Metal Pollution of Sewage Sludge from the Industrial City Yanbu, Saudi Arabia

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Abstract. Metal concentration of sewage sludge samples from the industrial city, Yanbu, Saudi Arabia were analyzed for cadmium, cobalt, copper, iron, manganese, nickel, lead and zinc respectively. All the samples collected from different sites in Yanbu city contain similar amount of metal concentrations and below the standards. Cadmium is very high in the tested sites. The study suggests that the use of sewage sludge as soil additive may give rise to pollution problems.

Introduction

Domestic sewage consists of household wastes, colloidal and dissolved materials, antiseptic detergents, pesticides, and other chemicals. Industrialization has created unique sewage disposal problems. Some industries produce very acidic waste materials, others produce alkaline wastes, and some contribute heavy metals, such as cadmium, copper, lead and zinc. Sewage disposal is one of the most important environment challenges in many areas of the world and being particularly difficult in areas where rapid industrial development is taking place. The heavy metal content of sludges from various countries has been published, particularly from Sweden, Great Britain, and The United States [1, pp. 39-47, 2, pp. 40-86 and 3, pp. 551-581]. Metals are recognized to have specific ecological, biological, and health effects. The application of sewage sludge

to agricultural land adjacent to sewage works is well established practice. In Saudi Arabia use of treated sewage sludge in the farms has become common. The value of sewage sludge as a source of macronutrients was assessed by several workers [4, 5, pp. 183-189, 6, 7 and 8]. and attention was drawn to the possible dangers from heavy metals present. Field experiments from other areas of the world reported high concentrations of heavy metals in applied sewage sludge [9-12].

The regulation do not allow land spreading of wastes with greater than the following concentration of metals: Cd 85 ug/g, Cu 4300 ug/g, Ni 420 ug/g, pb 840 ug/g, Zn 7500 ug/g (Federal Reg. 58 (32): 9248-9380 and 40 (FR parts 257, 403 and 503). It is clear from the present investigation, that only problem metal is cadmium. Sewage sludge treatments should done to protect the soils, crops and those who eat the crops from cadmium poisoning.

The present investigation determined the metal content of sewage sludge from the industrial city Yanbu to evaluate the risks of using the sewage sludge on agricultural lands.

Materials and Methods

Yanbu city is located about 350 km north of Jeddah at Red Sea Coast of Saudi Arabia; and is the corner stone of Saudi Arabia industrial development.

Raw sewage sludge samples were collected in sterile polyethylene bags from four applied sludge sites from Yanbu. Five subsamples from each site were taken and combined for chemical analysis. The samples were taken from domestic sources mixed with industrial waste at the depth of 0-30 cm. The pH of the samples recorded immediately (pH 6.5). Oven dried sewage sludge (20 g) was ground for 90 min. in a mechanical agate mortar.

The procedure was as follow: one-half grams of air dried sludge was placed in a 100 ml beaker with 15 ml concentrated nitric acid, covered with a watch-glass and heated at 90-100 °C for 30 min. After digestion, sample solutions were made up to 50 ml with deionized water and analyzed for Cd, Co, Cu, Fe, Mn, Ni, Pb and Zn using an atomic absorption spectrophotometer [13]. The acid extracted metal composition of 20 sewage sludge samples from 4 sites in the industrial city, Yanbu, Saudi Arabia, varied slightly (Table).

Table. Average acid extracted metal concentration in ug/g of 8 metals in 20 sewage sludge samples from the industrial Yanbu city, Saudi Arabia (n = 5, ± standard deviation)

| Metal | Sites | | | |
|-------|------------|------------|------------|------------|
| | 1 | 2 | 3 | 4 |
| Cd | 63 ± 0.9 | 49 ± 1.6 | 52 ± 1.1 | 57 ± 1.1 |
| Co | 80 ± 1.1 | 73 ± 1.1 | 83 ± 1.6 | 71 ± 1.8 |
| Cu | 882 ± 2.1 | 867 ± 2.1 | 873 ± 2.6 | 870 ± 2.9 |
| Fe | 1800 ± 3.4 | 1763 ± 3.9 | 1903 ± 3.9 | 1729 ± 3.9 |
| Mn | 103 ± 1.6 | 98 ± 1.3 | 99 ± 1.9 | 117 ± 2.1 |
| Ni | 385 ± 1.6 | 387 ± 1.2 | 390 ± 1.1 | 383 ± 1.8 |
| Pb | 189 ± 2.8 | 181 ± 1.3 | 183 ± 1.1 | 188 ± 1.2 |
| Zn | 741 ± 2.1 | 703 ± 2.6 | 789 ± 2.1 | 795 ± 2.1 |

Results and Discussion

The concentrations of Cd, Co, Fe, Mn, Ni, Pb and Zn were higher than earlier findings in some Saudi Arabian soils [14,15].

Jenkins and Cooper (1964) reported in England that acid digested sewage sludge contained 3730, 860, 6000 and 34300 ug/g of Cu, Ni, Zn and Fe, respectively. Berrow and Webber [4] stated that sewage sludges contained 1500, 260, 2500 and 3000 ug/g of Cd, Co, Mn and Pb respectively. Values determined in the present study, may be due to a lesser contamination of metals in the areas studied in Saudi Arabia as compared to areas studied in England which has a greater number of industries [9-12].

The high concentrations of metals in sewage sludge from land application [16, 17 and 18, pp. 129-143] could result in long term phytotoxic effects and food chain contamination.

As a result of field experiments carried out in the United States, Lunt [16] reported that the high level of Zn, Cu and Pb that most sludges contain could be toxic to plants in acid soils. Arnet [19] using evidence from pot experiments, concluded that such elements as Pb, Cd, Cu and Zn in sludges were only slightly available to crops, but suggested that they might accumulate in the soil.

Le Riche [20] reported that crops showed increased uptake of Cu, Ni and Zn, emphasizing the danger of these metals accumulating in soils following the repeated application of sewage sludge. The value of sewage sludge and similar materials as possible sources of N, P and K was assessed by field experimentation [2, pp. 40-86] and attention was drawn to the possible danger from metals sometimes present [21,22]. The concentration of Cd, Co, Cu, Mn, Ni, Pb and Zn in the present study were higher than earlier finding in some Saudi Arabian sludges [23].

Yanbu's industrial area accommodates several large refining and petrochemical plants, as well as a broad range of other manufacturing and support operations. The generally higher levels of cadmium [15, 16, 17, 18, pp. 129-143, 19, 20, 21, 22, 23] could be related to an increase of particular industries in the industrial city of Yanbu, Saudi Arabia.

In summary, the fact that the heavy metal contents are well below the standards and may make hazard for long run application as soil additives and probably build up potential hazards.

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التلوث المعدني بمخلفات الصرف الصحي لمدينة ينبع الصناعية المملكة العربية السعودية

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ملخص البحث. تم في هذه الدراسة تحليل المحتوى المعدني لمخلفات الصرف الصحي لمدينة ينبع الصناعية بالمملكة العربية السعودية، لعناصر الحديد، النحاس، الخارصين، النيكل، الكاديوم، المنجنيز والرصاص حيث وجد أنها متقاربة في تراكيزها في جميع العينات. كما لوحظ ارتفاع تركيز عنصر الكاديوم في العينات التي تم تحليلها. أوضحت نتائج البحث أنه على الرغم من تلك التراكيز المنخفضة عن القياسات العالمية إلا أن الاستمرار في استخدام مخلفات الصرف الصحي كسماد سوف يؤدي إلى زيادة تركيز العناصر المعدنية الثقيلة مستقبلاً.