Original Article

Assessment of Waste Production and Heavy Metal Emission from Energy Production Sector of Zahedan City

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Abstract

Background and purpose: Due to the lack of accurate statistics on the amount of waste generated in the energy production sector in Zahedan, before any planning, one should identify all waste producing centers associated with the energy sector and also the quantity and quality of their waste in Zahedan.

Materials and Methods: This research is a cross-sectional descriptive study. It examined the produced wastes in the electrical energy generation sector. A questionnaire was prepared and completed for each unit that possibility produces these wastes. Moreover, in the studied units, the weigh percent per unit was determined by separating production waste, and collecting and weighing them.

Results: In gas power plant of Zahedan, production of burned oil was approximately 480 liters and the annual consumption of turbine oil and compressor oil was 40 liters. In the diesel power plant, 2,200 liters of burned oil is produced for each generator after 1,500 hours of work. Concentration of heavy metals of Cr, Cd, Zn, Pb, Cu, and Ni in the burned oil sample of the gas power plant was 43.2, 0.01, 0.20, 1.3, 2.7, 0.2 mg/l, respectively; and in the diesel power plant were 36.3, 0.08, 0.09, 0.9, 4.7, 1.1 mg/l.

Conclusion: In the studied samples, several cases of heavy metal pollution were identified. Therefore, proper planning for appropriate management of these units is necessary for any possible leakage and environmental pollution transport. Furthermore, in order to minimize the adverse impacts of hazardous wastes on the environment and people in Zahedan, integrated hazardous wastes management should be practices in electrical energy generation plants. Moreover, one must consider the measures required to exposure, transport, and safe maintenance before managing or eliminating this type of waste.

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***Key words*:** Solid waste, Waste management, Power plant, Zahedan.

1. Introduction

The increasing use of chemicals in the industrializing world has resulted in many residual hazardous substances. Wastes produced due to increasing trend of consumption have reached to threatening levels in terms of quantity and hazardous content (1). In addition, in recent years, human has found that the loss of environment is synonymous with the loss of human life on Earth. In this regard, a factor that seriously threatens the environment is solid waste caused by various activities of human communities which will have adverse effects on the core elements of the environment, i.e. air, soil and especially water, if not managed truly (2,3). Since decades ago, planning in different areas of solid waste management began seriously in the world. Many advances have been made in controlling the production, collection and disposed of these materials. The amount of hazardous waste produced in recent decades has grown increasingly in the recent decade. Since 1980, hazardous waste management has been one of the most important issues in America so that during the last two decades, it has accounted for about 50 percent of the market of the whole environment issues. The main reason for this can be attributed to the sensitivity and awareness of people about the risks associated with the hazardous materials. In 1970, the US Congress considered hazardous waste in the range of hazardous solid waste. Then, the US Environmental Protection Agency (EPA) presented the importance of hazardous waste and inappropriate disposal methods in 1973 (3, 4).

Due to increase in incurable diseases like cancer and AIDS and hundreds of other diseases attributed to environmental pollution, since 1975 many countries have inevitably developed accurate and powerful legislation on optimal solid management so that before 1930 in America, the healthy disposal method was common and in 1960, Japan was the first country that began the control of hazardous waste management. In 1976, the US EPA established the Solid Waste Management Authority and in 1980, it enacted the Source Recycling Conservation Act (5). At present time, industrial hazardous waste materials have become a critical environmental issue in many different countries (1) and also in Iran. The energy sector (electricity and water) is one of the most important elements in developing countries which are followed by pollutants in air, water and soil. This study examines the wastes of two energy sectors (water and electricity). The first section (regional electricity) studies power plants and substations and the second section (water) investigates water and wastewater treatment plants. In general, the development of electricity generation is one of the major factors in the progress of civilization during the current century. In the electricity generation cycle, power plants generate waste which, in turn, leads to environmental hazards if discharged into acceptor environments without proper treatment processes. Among waste of power plants and substations, one can point to

wastes containing or contaminated with poly-chlorinated biphenyls, burned oil, general, paper, plastic, medicine, wood and metal waste, printer and copier toners, batteries and electrical and electronic boards, CFLs and fluorescents, oil-impregnated fabrics, etc. Poly chlorinated biphenyls compounds (PCBs) are a group of synthetic organic chemicals which are white and crystalline in pure form and their industrial compounds is a colorless liquid. These compounds readily dissolve in fats and accumulate in living bodies. Various experiments to show the effects of PCBs on different species showed that these compounds can adversely affect the immune, reproductive, and nervous systems and the endocrine secretion of these animals. Moreover, these materials cause cancer in these animals. Effects of these compounds in human includes incidence of bladder, liver and brain cancers in people exposed to this chemical (6).

All oils are contaminated during use by physical and chemical impurities and produce polar, resin and asphalt unsaturated compounds due to reaction with oxygen and decomposition upon heating. Moreover, lubes are smeared and mixed with dust, fuel types, carbon and metal particles and lose their effectiveness. Such oils are called used oil and should be replaced with new oil (7). To prevent damage or injury from possible contaminants in the future, it is necessary to identify and control pollutants of power plants. Therefore power plants must be examined in terms of waste quantities to ensure the proper functioning of all control systems and to fix faults in the control system and treatment plant, if any. In the second part, the waste of the energy sector in the water sector mainly includes waste of water and sewage treatment plants. Basically, sewage is the used water of any industrial unit or human that has lost its quality during use and in other words, it has been infected (5). During recent years, interest in industrial hazardous waste as an important source of energy and material has increased. Many industries are already engaged in extensive environmental audits and are evaluating their own waste management activities (8,9). Based on its results, this study can be used for waste planning and management, waste pollution reduction and yet the use of optimal management methods for safe disposal of waste. It can also provide necessary solutions to reduce the amount of waste in the electrical energy generation sector in Zahedan and to perform appropriate methods of waste collection, transport and disposal, aiming at health promotion and protection of biological resources (water, soil and air).

2. Material and Methods

1.2. Background information about the area of study

In addition to two power plants, the Zahedan city has a number of substations. Like many other cities in developing countries in Zahedan in the past few decades, the proper management of hazardous wastes has received little attention and they are usually disposed in the wrong way. This causes endangerment to public health, environmental health and the environment. At present time (2012), Zahedan has two power plants; gas type and diesel type. Zahedan gas power plant has a power generation capacity of nine 25-MW units in 1991. It was founded in a land with

an area of 500,000 m^2 in the 5th km of Gorband road. Zahedan diesel power plant has a power generation capacity of 22 MW. This power plant only operates at peak consumption. The wastewater treatment plant in Zahedan is located at a distance of approximately 2 km from the east side of the city with an area of 17.5 acres. It is located at a suitable distance from residential areas and allows the use of effluent for irrigation of green spaces in Zahedan. The average slope is 2.5 percent from East to West parts, and some parts of the land are as rocky outcrops. The groundwater depth in this area is low, about 80 meters from the ground (9).

2.2. Data collection

In this cross-sectional study, first a questionnaire was developed and completed containing waste type, explanation and example, and the custodian's behavior to examine the types of waste produced in power plants. Therefore, we found that what wastes with what quantity are produced. Then, in order to verify the status quo of managing wastes contaminated with PCBs (Askarel oil) in Zahedan and to provide appropriate management solutions, a questionnaire was also completed for each power plant and substation. Thus, information such as the name of the plant, power generation capacity, number of transformers, capacity or size of transformers, transformer lifetime, total number of people employed at the plant, total number of persons engaged in the environment of transformers and capacitors, total number of people responsible for evacuating oil from transformers, the way of their storage and disposal, etc. was acquired. In addition, in order to assess the quantity and quality of burned oil burning in power plants, necessary information was obtained from relevant authorities and required samples were taken to evaluate heavy metals.

3.2. Analysis

After acid digestion of burned oil samples with nitric acid according to standard procedures given in Standard Method 3030, the amounts of heavy metals (Cr, Cd, Zn, Pb, Cu, and Ni) were measured with the Graphite Furnace and the Atomic Absorption Spectrophotometer (Shimadzo AA7000) methods. Finally, all the collected data and information were analyzed (10,11).

3. Results

1.3. Heavy metal concentration of burned oil of power plants in Zahedan

In studies on the production of burned oil in the gas power plant in Zahedan, it was found that the annual consumption of motor oil is 480 liters, the annual consumption of turbine oil and compressor oil is 40 liters. All the oil values are collected from the power plant and are delivered to the Province Regional Electricity Company. In the diesel power plant, each generator produces 2,200 liters of burned oil after 1500 hours of working. But in this power plant, each generator averagely works 500 hours annually. Moreover, the compressor oil production is 10 liters per year in this power plant. Heavy metal concentrations in burned oil of the studied power plants of Zahedan were presented at Table 1. In addition, quantity of produced pollutants in the burned oil of the studied power plants as g/year was indicated. Furthermore, the quantities of produced wastes in power plants of Zahedan city were presented in Table 2.

Table 1. Heavy metal concentrations in burned oil of the studied power plants of Zahedan

Parameter	Heavy metals concentration, mg/kg					
	Cr	Cd	Cu	Zn	Ni	Pb
Burned oil of gas power plant	43.2	0.01	2.7	0.2	0.2	1.3
Burned oil of diesel power plant	36.3	0.08	4.7	0.09	1.1	0.9
Heavy metals concentration, g/year						
Burned oil of gas power plant	10	0.003	1	0.07	0.07	0.4
Burned oil of diesel power plant	170	0.37	22	0.42	5.1	4.2
Total	180	0.373	23	0.49	5.17	4.6

2.3. Chlorinated oils containing polychlorinated biphenyls

Studies revealed that Zahedan Regional Electricity Company has 11 transformers containing Askarel oil which are currently out of service. They contain approximately 1,100 kg of Askarel oil (with 100% containment with PCBs compounds). The necessary safety labels are installed on them and are ready to be delivered to authorized companies for proper disposal of these wastes.

Table 2. The quantity of produced wastes in power plants of Zahedan city

Kind of waste	Diesel power plant	Gas power plant
Domestic type	1-2, kg/day	4-5, kg/day
Paper	Very low	Very low
Plastic	1-2, kg/day	4-5, kg/day
Medical	Very low	Very low
Wood	-	200-250, kg/year
Metal	-	500, kg/year
Printer tuner and copy set	1-2, Cartridges/day	20, Cartridges/year
Batteries	-	-
Electronic boards	-	Very low
CFL and fluorescent	Very low	Very low
Oil-impregnated fabrics	2 kg/year	10 kg/year

Table 3. Comparison of attained results (heavy metals concentration in burned oil) of current study with similar studies

Reference	Heavy metals concentration, mg/kg					
	Ni	Cu	Pb	Zn	Cd	Cr
(11)	---	---	2570	980	2	11
(11)	---	---	240	480	3	6.6
(12)	---	---	33	822	1	1.4
(13)	22.5	96	213.5	1470	5.5	50
Gas power plant (current study)	0.2	2.7	1.3	0.2	0.01	43.2
Diesel power plant (current study)	1.1	4.7	0.9	0.09	0.08	36.3

4. Discussion

Review and analysis of the results of the questionnaires completed by experts in the studied power plants revealed that in both studied power plants, any possible leakage of transformers and the oil level are checked during visit. Transformers are checked for any possible leakage in both power plants on a daily basis. In both power plants, there are warning signs in the location of transformers and most drums containing waste oil. Due to various risks of exposure to these compounds, proper warning signs should be installed in these places. Implementation of programs for practical privacy and protection of units in all power plants and transmission posts appears necessary. Training staff and managers about the dangers of PCBs, burned oils and the exposure, control and management methods of contaminated items, isolation of contaminated items (including equipment, oils, clothing, dirt, and other contaminated items) and preventing leakage and direct contact of people with them, transport, maintenance and storage of contaminated items under the per-elimination terms of wastes containing PCBs, removal or destruction of contaminated items by authorized firms by Iran Department of Environment (IDOE), final monitoring to ensure the total management process in accordance with the IDOE guidelines and international conventions should be placed on the agenda. As presented in Table 3, heavy metals concentration in burned oil of current study is very lower than other studies (11-13). The deployment of Management Information System (MIS), especially the waste Geographical Information System (GIS) in the province, constant monitoring of power plant units for the management of generated wastes, continuous monitoring of water and wastewater treatment plant units for the management of generated wastes, daily waste collection from production centers of the energy sector by a contractor (water and electricity) and landfill in a site approved by the municipality and the IDOE, labeling the waste storage container or location to determine the waste type and its risks, suitable collection, storage and disposal of wastes contaminated with oil and petroleum materials, emphasis on presenting an action plan for managing wastes containing or contaminated with polychlorinated biphenyls under the agreement ratified by the Cabinet for related organizations, suitable collection, storage and disposal of oily waste and wastes containing heavy metals according to relevant laws and regulations, reuse of effluent and sludge resulted from sewage treatment for irrigation and fertilization of agricultural lands according to relevant laws and regulations should be considered. In addition, the treatment of used oil has to be done with proper care. All countermeasures should be taken to minimize any unreasonable risk to workers, public health and the environment. Experienced and qualified personnel well aware of the health and environmental risks associated should always perform oil treatment, strictly in accordance with local regulations. Furthermore, a full Risk Assessment should always be undertaken before commencing any treatment. According to results of this

study approximately 1,100 kg of Askarel oil (with 100% containment with PCBs compounds) were existed in 11 transformers which need to strength supervision.

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