FEATURE

Environmental and public health risks associated with chemical waste from research and educational laboratories in Dar es Salaam, Tanzania

This study presents a preliminary assessment of waste management practices in eleven laboratories of six educational and research institutions in Dar es Salaam, Tanzania. Categorical questionnaires were administered to 52 laboratory personnel to assess their awareness of health and environmental risks of chemical waste and the waste management practices. A chemical analysis was carried out to determine the nature, amount and composition of waste so as to assess the associated risk of environmental contamination and human exposure. The study found that liquid waste generated by the surveyed laboratories was mostly acidic in nature (pH = 1.2–3.4) and contaminated by elements such as Cu (0.02–3.44 mg/L), Cr (0.01–0.19 mg/L) and Pb (0.12–2.33 mg/L), in some cases above the safety limits. Generally, improper waste handling procedures were observed in terms of unlabeled waste containers (72.3%), lack of proper collection plan (75.0%), unsuitable means of disposal that included direct discharge into the drainage system (53.8%) and open dumping (42.4%) as well as lack of proper records of the waste quantities (55.8%). Regarding personnel awareness, >90% of the contacted personnel indicated that they were knowledgeable about pollution prevention concepts and impacts associated with chemical waste, while 25% had formal training on chemical waste management. The findings of this study raise awareness of the risks associated with chemical waste from this potential source and call for proper management of chemical waste, particularly to laboratory scientists and policy makers. It may also motivate a new generation of environmentally conscious scholars.

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INTRODUCTION

The potential risks of environmental contamination and human exposure associated with chemical waste from research and educational activities in Tanzania are not well addressed. For example, waste emission from this potential source is currently not addressed in the National Environmental Policy.[1] Furthermore, studies on hazardous waste management in the country have focused only on such sources as industrial activities, agriculture, mining and medical facilities.[2–5] This indicates that there is a lack of knowledge on the existence of a potential threat from educational and research institutions' laboratories as a source of chemical waste.

Educational and research laboratories conduct experiments for the training and research purposes in which chemicals of different nature and properties are used. In most cases, these laboratories are composed of different categories of people such as academic staff, technicians, researchers, administrative staff, students (bachelor, master and PhD) and sometimes visitors, making waste management of particular importance for the protection of human health.[6,7] As a general case, the environmental and public health concerns of poor management of chemical waste are widely discussed. These include possible leaching to the environment and subsequent contamination of surface and ground water, especially in the case of liquid waste,[8] effects to biodiversity[9] and possible occupational exposure leading to health effects.[10] A wide range of wastes may arise from a chemical laboratory in the course of conducting experiments.[11] Examples include liquids, such as aqueous solutions, oils and solvents; sludges, which

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can be both aqueous and non-aqueous; solid materials such as expired chemical reagents, used packaging materials and remains of samples. Gaseous emissions, such as those from laboratory fume chambers may be described as waste on their own wide definition.[12]

Currently there is a wide awareness of the need for proper control of waste from educational and research institutions. Various researchers have emphasized the importance of proper waste management practices in laboratories.[6,13] Institutions in various countries have developed their own guidelines for proper management practices for all aspects of the handling, storage, and disposal of chemical wastes.[14,15] Tanzania as one of the developing countries strives to achieve good waste management system. However, it is yet to establish standard policies and guidelines for chemical waste management for its educational and research institutions.[1] Some institutions in the country have formulated their own operation procedures for handling chemical waste while others are yet to do so.

In Tanzania, the number of research and educational institutions has kept increasing over the years. For example, whilst up to the mid 1980s there were only two universities and a handful of other specialist higher education colleges, by 2005 there were a total 30 universities, the majority of these being private. In addition, there were 15 additional public Institutions of Higher Education including six professional institutes and two institutes of technology.[16] A good percentage of these institutions are located in Dar es Salaam city, the economic and administrative center of Tanzania. With the advancements of science, technology and innovations as well as expansions of enrolments in different fields of specialization, the usage of chemicals in scientific laboratories of these institutions are likely to increase. Laboratories in these institutions range from those of chemistry, biology, chemical processing engineering, biochemistry, botany, zoology and aquatic science. All of them use different types of chemicals and reagents on a daily basis. This indicates potential discharge of significant amounts of chemical waste, including some possible hazardous materials to the environment.

Review of literature has shown that wastes from educational and research laboratories in Tanzania have not yet received sufficient attention. There is no documented study that investigated the production rate, the handling practices and the disposal procedures of waste from research laboratories in the country. The existing techniques and practices of chemical waste management, awareness levels and competency of laboratory practitioners in handling waste from this potential source are other important issues that are yet to be investigated. This study was therefore designed to preliminary assess the current chemical waste generation and the waste handling practices in the six institutions in Dar es Salaam City by determining levels of awareness of the practitioners, the quantities of wastes generated as well as their physical and chemical characteristics. The results are expected to serve as a baseline for more detailed investigation in the future and also used as a basis for making appropriate recommendations.

METHODS

Study Area and Design

Dar es Salaam city is located at 6°48′ South, 39°17′ East along the Indian Ocean coast and covers an area of 139.3 km^2. It is the largest city in the country and the most important for both business and government. The city has a population of about 4.4 million (2012 Census) representing 10% of the total Tanzania Mainland population. It consists of three local government areas or administrative districts namely Kinondoni, Ilala, and Temeke. Dar es Salaam City was selected for this research because it contains a significant number of academic and research institutions compared to the other parts of the country.

This study was designed to preliminary assess selected laboratories in Dar es Salaam City which include three academic institutions, namely University of Dar es Salaam (UDSM), Ardhi University (ARU) and Muhimbili University of Health and Allied Sciences (MUHAS); and three research institutions, namely Tanzania Bureau of Standards (TBS), Tanzania Government Chemist Laboratory Agency (GCLA) and Tanzania Food and Drugs Authority (TFDA).

Table 1 gives a summary of laboratories of the six institutions that were involved in this survey. Some of the institutions like UDSM and TBS had more than one laboratory specialized in research and academic activities that use a variety of chemicals for experiments, sample storage and research. Some of the laboratories like the GCLA, TBS and TFDA function as service laboratories providing services

Table 1. Summary of the Laboratories Involved in this Study.

Institution	Investigated laboratory	Code
UDSM	Inorganic Chemistry, Department of Chemistry	UDSM1
	Physical Chemistry, Department of Chemistry	UDSM2
	Organic Chemistry, Department of Chemistry	UDSM3
	Chemistry Laboratory, College of Engineering and Technology	UDSM4
TBS	Chemistry Laboratory 1	TBS1
	Chemistry Laboratory 2	TBS2
	Chemistry Laboratory 3	TBS3
ARU	Environmental Engineering Laboratory	ARU1
MUHAS	Chemistry Laboratory, Institute of Traditional Medicine	MUHAS1
GCLA	Chemical Management Division	GCLA1
TFDA	Chemistry	TFDA1