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Assessment of Environmental Aspects and Impacts of Scientific Laboratories of a University: Focus on Gap Analysis and Environmental Management System (EMS) Implementation

Tanveer Mehedi Adyel[1,2]*, Fayezun Nahar Begum[3], S. M. Nazrul Islam[4,5], Muhammad Hafizur Rahman[4]

[1]School of Environmental Systems Engineering, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia
[2]Department of Environmental Science, Z. H. Sikder University of Science & Technology, Bhedergonj, Shariatpur 8024, Bangladesh
[3]Bangladesh Oil, Gas & Mineral Corporation (Petrobangla), Petrocentre, Dhaka 1215, Bangladesh
[4]Department of Environmental Sciences, Jahangirnagar University, Dhaka 1342, Bangladesh
[5]Department of Environmental Science and Engineering, School of Natural Resources and Environmental Studies, University of Northern British Columbia, 3333 University Way, Prince George, BC, V2N 4Z9,Canada

Abstract

Environmental Management System (EMS) has become an important tool for organizations looking towards managing their environmental issues such as pollution, legal compliance and minimizing their environmental impacts. The present study was conducted to assess the environmental aspects and impact of selected scientific laboratories of Jahangirnagar University in Bangladesh with focus on the gap analysis for implementing EMS. Data and information were collected through frequent laboratory visits, focus group discussion, questionnaire survey and key informant interview. It was found that EMS was not implemented in the laboratories and the staffs and researchers of the university had very limited idea about EMS. Surface water, air and soil pollution; unsafe mixing and handling of hazardous materials and chemicals; unsustainable storage of chemicals and reagents; improper use of personal protective equipment *etc.* were found as the main environmental challenges in these laboratories. The maximum negative environmental impact occurred in the chemistry and botany laboratories, as large number of researchers' here used high amount of chemicals and cultured media, while the minimum pollution was found in microbiology and environmental sciences laboratories. Although, the overall pollution levels were low, there were lots of gaps in introducing EMS. Therefore, initiatives should be taken.

Keywords:*Impact Score Sheet, Degree of Impact, Frequency of Impact, Pollution Index, Gap Analysis, Management System, Environment.*

Introduction

Among the diverse environmental management practices *viz.*, cleaner production, eco-efficiency, life cycle assessment *etc.* that large companies have adopted in the recent years, certified Environmental Management System (EMS) has been receiving the maximum attention (Link and Naveh, 2006; Viadiu*et al.*, 2006; Albuquerque *et al.*, 2007; Salomone, 2008; Campos, 2012). An EMS considers a company's organization through a thorough review of operations and analyses how a company's activities affect the environmental compartments (ISO 14001,2004). Numerous

*Corresponding Author (tanveeradyel@gmail.com)

studies have been conducted around the world on the implementation of EMS and its benefits (Hillary, 2004; Ávila and Paiva, 2006; Gavronski*et al.*, 2008; Ridolfi*et al.*, 2008; Jabbour, 2010; Heras-Saizarbitoria*et al.*, 2011). In broad sense, EMS serves as a tool to improve companies' environmental performance; provides a systematic way of managing an organization's environmental affairs; give order and consistency for organizations to address environmental concerns through the allocation of resources; assignment of responsibility and ongoing evaluation of practices, procedures and processes; certify their achievements and focus on continual improvement of the system (IAF, 2001; Jain and Rao, 2006). It is noteworthy that organizational improvements in environmental performance are beneficial not only for the environment, but also for a positive relationship between improved environmental and corporate performance (Bonifant and Ratcliff, 1994; Porter and Van der Linde, 1995; Klassen and McLaughlin, 1996; Melnik*et al.*, 2003; Hillary, 2004; Pombo and Magrini, 2008; Seiffert, 2008; Heras and Arana, 2010; Campos, 2012).

More recently, educational institutions such as universities are following EMS, which brought forward by the debate about campus sustainability (Disterheft*et al.*, 2012). They aim to reduce their environmental impact and with special regard to universities, embrace the 'environmental imperative' and integrate systemically sustainability into higher education institutions (Weenen van, 2000; Sharp, 2002; Cortese, 2003; Hansen and Lehmann, 2006; Lozano, 2006; Adomssent, *et al.*, 2008; Heras and Arana, 2010; Disterheft*et al.*, 2012). Campus sustainability, in term of laboratory, links both the operational aspects of teaching, research and institutional administration, like reducing energy consumption, emissions, materials, laboratory waste, reducing mismanagement of chemical and reagents and improvement of waste management practices, as well as the educational aspect to develop new practices and life style concepts that take into account the wellbeing of current and future generations(Disterheft*et al.*, 2012). EMS at the campus level can be used in a broader sense beyond campus operations; combining the dimensions of education, research, relationship with stakeholders as well the continuous strive for improvement through assessment and reporting (EPA, 2000; Ferreira *et al.*, 2006; Nicolaides, 2006).

EMS contains seventeen key elements based on mainly the "Plan, Do, Check, Act" model, also known as Deming Cycle, introduced by Shewart and Deming (Figure 1). In fact, environmental aspect is the element of an organization's activities, products or services that can interact with the environment, while environmental impact is any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services (Stapleton*et al.*, 2001). The relationship between aspects and impacts is often one of cause and effect. Environmental aspect is neutral but environmental impact can be either positive (such as making a product out of recycled materials) or negative (such as discharging toxic materials to a stream) (Stapleton*et al.*, 2001). In small laboratory, although diverse works are executed, environmental management is most likely a shared responsibility or administer by part time staff or through collateral duty. These laboratories have some advantages over larger laboratories for establishing an EMS, for example, lines of communication are generally shorter, organizational structures are less complex, people perform multiple functions and access to management is simpler (EPA, 2000).

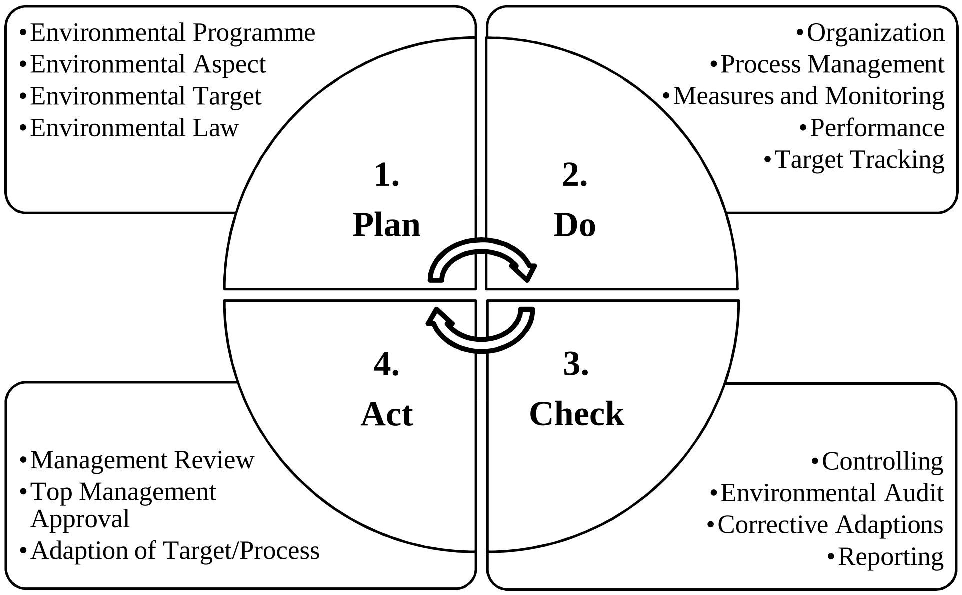

Figure1. Basic concept of "Plan, Do, Check, Act" model of EMS

Nevertheless, to the best of our knowledge, no investigations of regular surveys, monitoring and assessment have been reported about the practicing of EMS in any scientific laboratories of academic institutions in Bangladesh. The aim of present study was to assess the environmental aspects and impacts of selected scientific laboratories of Jahangirnagar University (JU), Bangladesh. The study was ultimately focused on the gap analysis for implementing EMS.

Materials and Methods

Data Collection

A structured questionnaire was surveyed to collect data and information regarding environmental aspects and impacts of laboratories of two faculties *i.e.*, (a)Physical and Mathematical Sciences, and (b) Life Sciences of JU. The university is located in SavarUpazilaof Dhaka District, Bangladesh. Chemistry (Organic, Inorganic and Physical), Environmental Sciences, Biochemistry & Molecular Biology, Botany, Microbiology, Pharmacy and Zoology laboratories were under investigation. Laboratory observation, Focus Group Discussion (FGD) and Key Informant Interview (KII) were also conducted to formulate the environmental impact scoring index and assess knowledge level of laboratory personnel about EMS.

Environmental Aspect and Impact Scoring Worksheet or Index

For each product, service or activity (or group of products, services or activities) and each element was assigned two scores based on (a) the degree of impact, and (b) frequency or likelihood of the associated environmental impacts (Table 1). Scores were added for each indicator across the relevant life cycle stages to generate a total impact score. Major activities in scientific laboratories included storage, mixing, use and waste management. Storage indicated the time of storing any chemical or material by researcher, which may affect the environment if release accidentally. As like storage, mixing indicated the time of mixing any chemical or material with other chemical by researcher, which may affect the environment if any accident occurs. Waste management indicated that if there is any management or treatment process present in the lab and type of waste produced which is harmful for health and environment and its possible impact to the environment. Main indicators included researcher, surrounding communities, air quality, soil/land surface water, ecosystem, noise, fuels, water and raw materials.

Table 1: Scores and meaning of degree of impactandfrequency or likelihood of impact

Degree of Impact	Score	Frequency/Likelihood of Impact
Serious (likely to result in severe or widespread damage to human health or the environment)	4	Continuous (impact occurs on an on-going basis)
Moderate	3	Frequent (impact occurs more than once/month)
Minor	2	Infrequent (impact occurs more than once/year but less than once /month)
No impact (unlikely to have an adverse impact on human health or the environment)	1	Improbable/never (impact has never occurred or is highly unlikely to occur)

Significance Level of Total Score

The total score of an indicator was divided into four categories (Table 2). Stapleton et al.,(2001) developed the method of evaluating impact score sheet of any organization. Total score of an indicator was the summation of the processes scored of the laboratory (Equation 1). Finally, a pollution index was also calculated.

Total Score to Different Category= (Degree of Impact + Frequency of Impact) (Storage + Mixing + Use + Waste Management) (1)

Table 2: Range of significance level of impact to environment

Total Score	Significance Level of Impact
8-16	Low or no significant impact to the environment
17-24	Moderate significant impact to the environment
25-32	High significant impact to the environment
>32	Severe impact to the environment

Results and Discussion

From laboratory inspection, questionnaire survey, FGD and KII, an overview of EMS, environmental aspects and impacts and their gaps were found. Department of Chemistry had the maximum number of laboratories (12). Researchers used various types of acids, bases, salts, resins, polymers, pigments, dyes, huge amount of water (raw and distilled water) *etc*. for their research purposes. Some of these chemical were highly toxic for human health, plants, animals and environment, and listed as hazardous toxic substance by Occupational Safety and Health Administration (OSHA). Solid waste including broken apparatus, filter papers *etc.* were deposited in the dustbin of the laboratory and finally disposed besides the department. Environmental aspects and impacts score for human heath, environment and resource use category of chemistry laboratory were given in Figure 2. Score for researcher and surrounding community from organic laboratory of chemistry department was 17 and 18, respectively (Table 3) that was belongs to moderate significant impact to the environment. As the maximum liquid wastages were drained through pipe and discharged into the lake situated in front of the department, this laboratory also contained high environmental aspects and impacts score in respect of surface water (Table 3). Both inorganic and physical laboratories of chemistry department cause low to no significant impact to the environment (Table 3).

In biological and chemical laboratories of the Department of Environmental Sciences different chemical reagents and biological media were used. All the sub indicators showed low or no significant impact to the environment from this department (Table 3). As the number of student was less compared to the department of Chemistry, pollution from different activities was also minor here. Environmental aspects and impacts score for human heath, environment and resource use category of the laboratories were given in Figure 2. Like Environmental Sciences, all indicators of the Department of Biochemistry and Molecular Biology had a score of 8-12 indicating low significance level of impact (Table 3).

Department of Botany contained six laboratories *viz.,* plant ecology conservation, plant tissue culture, plant pathology, plant physiology, plant breeding and plant systematic laboratory. Various chemicals, nutrient agars, pesticides, fertilizer, alcohols *etc.* were used in these laboratories round the year. The total score of researcher and human health category were 20 (Figure 2& Table 3) that belonged to moderate significant environmental impact. The surrounding communities had a score of 13 which indicated low significant environmental impact. Except air quality and ecosystem indicators, all indicators of both environment and resource uses hold score between 8 and 14 indicating low significant environmental impact.

After microbiological tests, all materials and equipment of the Department of Microbiology were autoclaved to remove pathological contamination. Except researcher, in human health category all indicators scored from 8 to 14 (Table 3) that indicated low significant pollution to the environment. Department of Pharmacy was consisted three laboratories-two common practical and one thesis laboratory. Except air quality indicator, all other indicators of these laboratories contained scores (Table 3), that indicated low significance impact of the environment. Moreover, except the indicator of researcher, all indicators fall into the low significance environmental impact to the environment. But working of researcher in category human health indicated the lab process moderate impact on environment that ultimately harmful for health. The maximum individual score was also from researcher activity in laboratories *i.e.,* using chemical and waste management processes.

Table 3: Environmental aspects and impacts score sheet of selected scientific laboratories of JU

Indicators Name of Department	Human Heath Category		Environmental Category						Resource Use Category		
	RS	SC	AQ	LS	SW	EE	GW	N	F	W	RM
Chemistry (Organic)	17	18	12	20	20	14	8	8	16	10	12
Chemistry (Inorganic)	10	10	8	12	12	10	8	8	12	10	12
Chemistry (Physical)	10	10	12	12	12	10	12	8	12	10	12
Environ. Sci.	10	10	12	12	12	10	8	8	12	10	12
Biochem. & Mol. Bio.	10	10	12	12	12	10	8	8	12	10	12
Botany	20	13	20	14	14	20	8	12	12	10	12
Microbiology	20	13	8	14	14	14	8	12	12	10	12
Pharmacy	10	10	20	12	12	10	8	12	12	10	12
Zoology	20	13	8	14	14	14	8	12	12	10	12

[Environ. Sci.: Environmental Sciences; Biochem. & Mol. Bio.: Biochemistry & Molecular Biology; RS: Researcher; SC: Surrounding community; AQ: Air Quality; LS: Land/Soil; SW: Surface Water; EE: Ecosystem Effects; N: Noise; F: Fuels; W: Water, RM: Raw Materials]

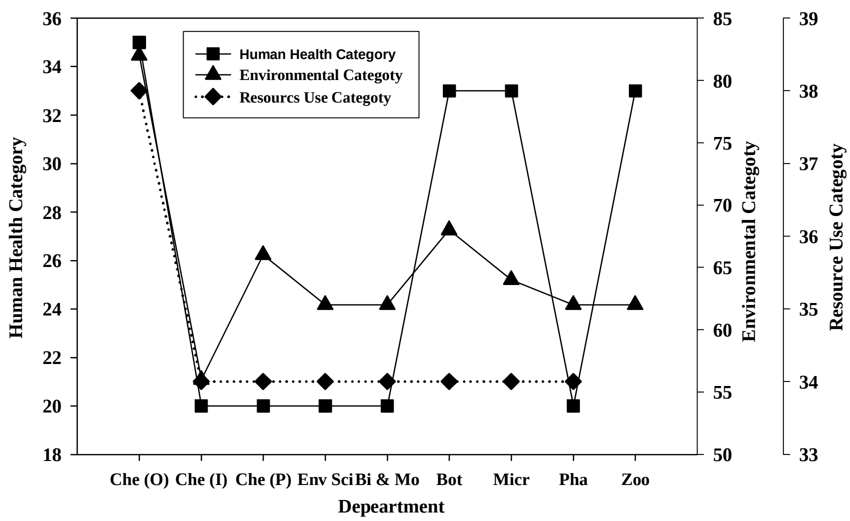

Figure 2. Significance level of total score of environmental aspects and impacts of different indicators[Che (O): Chemistry (Organic); Che (I): Chemistry (Inorganic); Che (P): Chemistry (Physical); EnvSci: Environmental Sciences; Bi & Mo: Biochemistry & Molecular Biology; Bot: Botany; Micr: Microbiology; Pha: Pharmacy and Zoo: Zoology]

On the basis of data and information the significance level of total score to the environmental segment was given in Table 4.

Table 4: Pollution index of selected scientific laboratories of different departments of JU

Name of the Department	Air Pollution	Soil Pollution	Noise Pollution	Surface Water Pollution	Ground Water Pollution
Chemistry	**	**	++	**	++
Environmental Sciences	++	++	++	**	++
Biochemistry & Molecular Biology	++	**	++	**	++
Pharmacy	**	++	++	**	++
Zoology	++	**	++	**	++
Botany	**	**	++	**	++
Microbiology	++	++	++	**	++

Legend

Low	++
Medium	**
High	##
Very high	©©
Severe	

Surface water pollution was categorized as medium significance level of pollution in respect of all laboratories. All 10 artificial lakes of JU are connected to each other and pollution of one lake may harmful for other. There was low or no pollution index in the case of noise pollution and ground water pollution. Soil pollution index was medium in case of Chemistry, Biochemistry & Molecular Biology, Zoology and Botany laboratories. Environmental Sciences and Microbiology laboratories had low pollution than all other laboratories. The pollution level of all laboratories of JU can be shown as: Chemistry (Organic) > Chemistry (Physical and Inorganic) > Botany > Zoology > Biochemistry and Molecular Biology > Pharmacy > Microbiology > Environmental Sciences. Surface water pollution was caused by all laboratories. The selected scientific laboratories did not implement any EMS and they had no idea about it. Main gaps included lack of proper knowledge about various elements of EMS, communication, toxicity monitoring, environmental awareness, pollution prevention initiatives, safety measures, personal protective equipment, emergency preparedness, proper monitoring *etc.* When all of these were settled, then EMS can be implemented.

Conclusion

EMS is a vital issue in environmental performance development for small laboratories. No EMS is present in all laboratories, and various environmental impacts and aspects were identified which may cause pollution of different segment of environment. Main environmental aspects and impacts of laboratorieswere wastewater containing chemical discharge in the nearby lake. Other aspects were material storage and handling, solid waste, soil pollution *etc.* Chemistry and Botany laboratories caused higher of pollution than other laboratories. Zoology, Pharmacy and Biochemistry & Molecular Biology laboratories may cause medium pollution whereas less in Environmental Sciences and Microbiology laboratories. However, the overall environmental impacts were low but it is needed to implement the EMS and determine the actual rate of pollution and impact from these laboratories toward the environment.

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