

Involving students in monitoring occupational risk at a battery recycling facility

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ABSTRACT: Described in this paper is a project undertaken by students and faculty members in the Environmental Engineering and Protection in Industry study programme in the *Lucian Blaga* University of Sibiu, Romania, concerning the impact of lead pollution at a battery recycling facility, where lead is recovered from spent batteries. The main objective was to monitor the occupational risk and to involve students in practical activities related to their field of study. Students carried out measurements at different workplaces within the company, monitoring pollutants in the atmosphere and among a group of 32 workers (e.g. the level of lead poisoning in the human body). Values for inorganic lead in the atmosphere exceeded legal limits by 2 to 8 times and there were high rates of plumbemia among workers. Based on these results, the students, under supervision of specialist faculty members, recommended several measures for the improvement of the working and environmental conditions. The results of these researches were also used in the diploma projects of some of the students.

INTRODUCTION

The Faculty of Engineering is one of the largest faculties of the *Lucian Blaga* University of Sibiu, Romania. Students are taught various areas of engineering, from industrial to electrical engineering, computers, industrial business management and environmental engineering.

The study programme Environmental Engineering and Protection in the Industry is one of the newer study programmes, and reflects the current trend towards an ecological approach to daily life and, especially, to the workplace environment. Students are taught both the principles and procedures of industrial engineering, as well as subjects specific to the area of environmental protection, such as waste management; techniques and equipment for the depollution of air, water and soils; and environmental and occupational risk assessment.

To prepare students from this study programme for their future jobs, efforts have been made by faculty members to involve students in practical research activities that resemble those the graduates would need to carry out as part of their jobs and to give them the opportunity to develop practical critical thinking and analysis skills.

This paper describes a research activity, carried out by students, under the supervision of the authors of the paper, at a battery recycling facility in the town of Copsa Mica, in central Romania. Levels of lead in the environment and the workers were evaluated, and measures suggested to improve problem areas. Copsa Mica was once ranked as the most polluted town in Europe and, despite intensive efforts to improve the situation, there are still problem areas that need to be addressed.

Lead is a natural element intensively used by humans since the dawn of civilisation. Its various uses have led to its being present in all human bodies, as a result of exposure to anthropogenic sources [1][2]. The amount of lead in the human body is comparable in magnitude to concentrations that result in adverse effects [3]. Therefore, it is important for human and environmental health to constantly monitor the level of lead-containing emissions in the atmosphere and also the amount of lead making its way into the bodies of workers who are in daily contact with potential sources of contamination. While previous studies on this matter are found in the literature [3-6], it is imperative to get as much data as possible from various affected areas, so that specific and effective measures can be taken for each particular situation.

This research provided a good opportunity for the students to get involved in activities that are directly linked to their field of study and to learn more about the threats to the environment, and also about their future role in society as promoters and guardians of a healthy and natural work environment.

SUBJECT, OBJECTIVE AND PARTICIPANTS IN THE ENVIRONMENTAL MONITORING ACTIVITY

The company monitored during this research produces lead ingots from material recovered from spent and discarded car batteries, so that these ingots can be used in the production of new batteries.

The main production stages comprise:

- dismantling of spent batteries;
- melting of the lead-containing waste resulting from the dismantling;
- refining and obtaining molten raw lead;
- casting lead into ingots;
- treating the electrolyte and the wastewaters.

Based on a co-operation project between the company and the University, faculty members and students were invited to monitor the environmental conditions in critical production areas and to suggest improvements.

The main objective of the monitoring was to assess the occupational risk in this company by determining, on the one hand, the hazardous emissions into the atmosphere in the workplaces throughout the company and, on the other hand, the impact of the working conditions on the workers. The study monitored 32 workers during the period 2010-2012.

The study was carried out by a mixed team of four faculty members and ten students from the Environmental Engineering and Protection in the Industry study programme.

METHODOLOGY OF THE MONITORING ACTIVITY

The students, assisted by the co-ordinating faculty members, first analysed the toxic emissions into the atmosphere of three workplaces considered as relevant to determine lead emissions into the atmosphere viz. feeding the melting furnace, feeding the ingot casting pot, cutting the spent batteries.

In order to assess the response of the workers to the lead pollution in their workplaces, a representative sample of 32 workers was selected. The students measured parameters, such as the blood lead concentration (Pbu), urinary delta aminolevulimic acid (DAL-U) and plumbemia (Pbs).

The students performed the tests over two years viz. 2010 and 2012. Between these tests, the company improved their technological and ecological systems; for example, by installing exhaust systems in the melting and casting areas.

According to current legislation, to determine the organic lead present in the atmosphere, samples must be taken in two ways: once continuously for a total duration of 15 minutes and once every hour for a total duration of 8 hours.

The students learned to use a Gillian pump to take samples from the air exhaled by the tested workers. The air samples were then analysed in the laboratory through atomic absorption spectrometry (Figure 1).

Figure 1: Student loading a sample into the atomic absorption spectrometer.

For assessing the plumbemia, the students used the anodic voltammeter technique with a Lead Care System apparatus on capillary blood samples obtained by puncturing a finger (Figure 2).

For assessing the blood lead concentration, the students analysed urine samples with the spectrophotometry technique.

The amount of urinary delta aminolevulimic acid was then determined using a rapid spectrophotometric sampling method, based on the condensation reaction with reactants, such as acetyl-acetone and sodium acetate, glacial acetic acid and fuxin, the complex being coloured red by the Ehrlich reactant.

Figure 2: Student taking a blood sample for assessing plumbemia.

RESULTS OF THE MONITORING AND THEIR INTERPRETATION

As can be seen from Table 1, the team involved in this research in 2010 measured very high levels of lead in the air exceeding the legal limits by up to 8 times. It was left to the students to suggest improvement measures and one suggestion was to introduce exhaust systems in critical areas, especially furnace feeding and casting pot feeding.

Table 1: Results of the preliminary determination of inorganic lead in the workplaces atmosphere, 2010.

Area	Lead in the air 2010 (8 hours) mg/m^3			Lead in the air 2010 (8 hours) mg/m^3		
	Determined value	Legal limit	Times legal limit	Determined value	Legal limit	Times legal limit
Furnace feeding	0.398	0.05	7.96	0.398	0.1	3.98
Casting pot feeding	0.224	0.05	4.40	0.22	0.1	2.20
Battery cutting	0.200	0.05	4.00	0.20	0.1	2.00

Following these results and the recommendations made by the students for improving the working conditions, the management of the company decided to implement the suggestions and added exhaust systems.

The effects could be seen when the measurements were repeated in 2012 (Table 2), with a reduction of up to 40% in toxic emissions compared to 2010 levels.

Table 2: Results of the determination of inorganic lead in the workplaces atmosphere, 2012.

Area	Lead in the air 2010 (8 hours) mg/m^3			Lead in the air 2010 (8 hours) mg/m^3		
	Determined value	Legal limit	Times legal limit	Determined value	Legal limit	Times legal limit
Furnace feeding	0.260	0.05	5.20	0.260	0.1	2.6
Casting pot feeding	0.141	0.05	2.82	0.141	0.1	1.41
Battery cutting	0.141	0.05	2.82	0.141	0.1	1.41

With regard to the blood lead concentration level, Table 3 presents the average values for the 32 monitored workers, while Table 4 presents a breakdown of the number of workers with various levels of blood lead concentration. It can be noticed that while there is a slight decrease in the level for 2012, it is still alarmingly high and there is a need for more determined measures to bring the levels within safe limits.

The participating students had the opportunity to discuss the results of the monitoring processes from 2010 and 2012, and to suggest measures that the company should take to comply with all regulations concerning toxic emission levels and occupational safety.

Table 3: Results of determining the level of blood lead concentration, 2010 and 2012.

Area	Blood lead concentration 2010 µ/dl	Blood lead concentration 2012 µ/dl
Furnace feeding	179	170
Casting pot feeding	181	178
Battery cutting	187	185

Table 4: Numbers of workers with a certain level of blood lead concentration, 2010 and 2012.

Area	Pbu < 150 µ/dl		Pbu 150-165 µ/dl		Pbu 165-180 µ/dl		Pb > 180 µ/dl	
	2008	2010	2008	2010	2008	2010	2008	2010
Furnace feeding	4	9	9	6	9	8	8	6
Casting pot feeding	5	7	11	8	7	9	9	8
Battery cutting	5	6	10	9	8	7	9	8

CONCLUSIONS

The implementation of modernisation recommendations has led to a decreasing trend both with regard to the values of the toxic emissions at the workplaces and in the workers' blood lead concentrations, even though the values are still over the legal levels. This has led the research team to the conclusion that the current practices in the company are still insufficient and unsatisfactory. Therefore, the team recommended a reducion in the work day from 8 to 6 hours, so that workers are less exposed to unhealthy working conditions, i.e. to reduce the inhalation of lead-bearing powders and gases.

Also, it has been recommended that the company study and implement the BATNEEC (Best Available Techniques Not Entailing Excessive Costs) for their industry and to integrate waste management activities into their overall economic activity. Among other measures, the mixed team, consisting of students and faculty members, recommended the careful sealing of the workshops and, especially, of equipment producing lead-containing gases, vapours or powders. Also all rooms should have installed adequate ventilation systems and systems for the evacuation of the lead-containing gases, vapours or powders.

The participating students had the opportunity to gain insight into the activity of an environmental engineer; into the main problems and risks present in the industrial environment of Romania in which they will need to operate after finishing their studies.

REFERENCES

1. Flegal, A.R. and Smith, D.R., Current needs for increased accuracy and precision in measurements of low levels of lead in blood. *Environmental Research,* 58, **2**, 125-133 (1992).
2. ATSDR/CDC Subcommittee Report on Biological Indicators of Organ Damage. Atlanta, GA, USA (1999).
3. Budd, P., Montgomery, J., Cox, A., Krause, P., Barreiro, B. and Thomas, R.G., The distribution of lead within ancient and modern human teeth: implications for long-term and historical exposure monitoring. *SCI TOTAL ENVIR - Science of The Total Environment*, 220, **2**, 121-136 (1998).
4. Habal, R., Toxicity, Lead. Department of Emergency Medicine, New York Medical College (2004).
5. Agency for Toxic Substances and Disease Registry (ATSDR), Case Studies in Environmental Medicine: Lead Toxicity, US Department of Health and Human Services (2000).
6. Levin, S.M. and Goldberg, M., Clinical evaluation and management of lead-exposed construction workers. *Am J Ind Med*, 37, **1**, 23-43 (2000).