Environmental Impact Assessment for an Optometry Manufacturing Industry

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Abstract

The optometry waste being generated from the optometry industry under study includes cutting, smoothing and polishing waste. During the glass smoothing and polishing stage the liquid has a pH of 11.80 and 11.05 respectively. This basic pH can be neutralized by adding a mineral acid like sulphuric acid. The plastic glass smoothing stage produces acidic liquid waste of around 4.70. This pH can be neutralized by adding calcium hydroxide before disposal into the municipal system. The optometry waste had high solids content ranging from 0.8-10.1 g/L and these must be filtered off and disposed off safely in metal containers or plastics. A proper environmental management plan must include proper record keeping, training of personnel and managing of multi-hazardous waste.

Keywords
Environmental management, lenses waste management, optometry industry**,** wastewater management

1. Introduction
The optometry industry generates a lot of waste due to its various processes such as cutting, polishing and washing. This waste has potential to negatively impact the environment hence the need for its proper management (Amini and Crescenzi., 2003). This can be achieved through reuse, recycling, waste reduction and recovery. The review of production processes is therefore critical to make sure they are efficient. Details of how the environmental management will be done, monitored and implemented must also be done. This paper therefore focused on the assessment of the environmental waste management for an optometry products manufacturing company. Environmental management issues associated with small laboratories present a unique challenge. This challenge stems from the fact that most of today's environmental management requirements are based on regulations which were designed for relatively simple processes in manufacturing The uniqueness of small lab operations means that traditional approaches to environmental management, which may work well with other operations, need careful consideration, and possibly adjustment, to work well.

2. Description of Organization under Study
The organization in question deals in optometry lenses manufacturing, besides other health related activities in other divisions. The health facility organization is situated in Harare, Zimbabwe. Spectacle lens production can be divided into three processes. Basically there are three process lines in the spectacles/ lenses production in the organization. These processes are spectacle lenses production from glass, spectacles lenses production from plastics and coating process. These processes use different types of materials and chemicals and they generate waste of different physical and chemical composition.

3. Materials and Methods
3.1 Determination of the effluent characteristics
The characteristics of the effluent generated were characterized using the APHA (APHA, 2005) standard methods. The concentration of the total dissolved solids (TDS) and total suspended solids (TSS) was measured in milligrams per liter (mg/L).

3.2 Preparation of 5L 0.01M sulphuric acid from 98% sulphuric acid

Take 2.7mL of 98% sulphuric acid and put in a 5L container. Add distilled water to the 5L container up until it's full. This will result to a 0.01M sulphuric acid solution

3.3 Neutralization of pH for the glass smoothing and polishing liquid

To neutralize the pH of 11.80 and 11.05, add the 0.001M sulphuric acid slowly while stirring the mixture. Use a pH meter to check if the pH has adjusted to the required range. If not continue adding acid until you have reached the required pH range. NB: Do not forget to keep on checking with the pH meter after adding any acid increments.

3.4 Neutralization of pH from plastic polishing liquid

Add 0.01M calcium hydroxide solution slowly while stirring to the solution which needs to be adjusted the pH. Dip a pH meter electrode to check the pH of the effluent, keep on adding until the required pH is achieved. Keep in mind to continue monitoring the pH with the pH meter after adding the 0.01M calcium hydroxide.

4. Processes Involved and Waste Disposal Methods

4.1 Glass Lenses Production Line

The process has three different unit processes which involve: cutting, smoothing and polishing (Guerrero et al., 2013). The glass lenses production line and waste generated is indicated in Table 1.

Table 1. Details of Glass Lenses Making Process, Procedure and Waste Generated

Process	Procedure	Waste Or Effluents And Characteristics	Treatment	Disposal
Cutting	• Lens blanks are received from the storage and appropriate blanks are selected. • Large glass lenses are loaded into lens meter Machine and fixed into position. • The lens blanks is cut/grinded into desirable size and shape and small dust/ offcuts are generated	• Minute glass offcuts are generated. • Glass is mainly composed of silica.	Silica directives, just like sand can be co-deposited and a general MSW disposal site.	Disposal site in Pomona Municipal Disposal site. The glass waste is deposited in 20 Liter bins and emptied after once every three months.
Polishing	• 10 liter of water is mixed with 2.5kg of abrasion chemical. • The mixture is continuously brought in contact with the lens in a smoothing machine resulting in abrasion effect causing smoothing of the surface. • The mixture is recycled and used for a month before disposal.	• After a month the effluent is emptied to a 20 liter plastic container.	The main chemical content is aluminum oxide.	The pH of the effluent is tested**.**
Smoothing/ Fining	• A glass lens is loaded into smoothing/fining	**Waste Type**	No treatment is done and the waste is loaded	To be disposed of at Pomona MSW dump.

	machine and fixed • The fining machine rotates the pads in a circular motion while a polishing compound consisting of aluminum oxide, water, and polymers flows over the lenses.		into 20 liter bin.	

4.2 Plastic Lenses Production Line

The process has three different unit processes which involve: cutting, polishing and smoothing. The detailed process for plastic lenses, procedure and waste generated is indicated in Table 2.

Table 2. Detailed process for plastic lenses, procedure and waste generated

Process	Procedure	Waste Or Effluents And Characteristics	Treatment	Disposal
Cutting	• Large CR39 plastic lens blank are loaded into lensometer machine and fixed in position • The plastic is cut into desirable size and shape. • A vacuum cleaner is used to collect the plastic offcuts which are in dust particle size.	• Minute plastic offcuts are generated. CR39 Plastic is composed of monomers and does not easily degrade.	No treatment is required but co-disposal at the MSW disposal site.	Disposal site in Pomona Municipal Disposal site. The plastic waste is deposited in 20 Liter bins and emptied after once every three months.
Polishing	• 10 liter of water is mixed with 25kg kg of abrasion chemical. • The mixture is brought in contact with the lens in a polishing machine resulting in abrasion effect causing smoothing of the surface. • The mixture is recycled and used for a month before disposal.	• After a month the effluent is emptied to a 20 liter plastic container.	The main chemical content is aluminum oxide.	
Smoothing /Fining	• A plastic lens is loaded into fining Machine and fixed • The fining machine rotates the pads in a circular motion while a polishing compound	**Waste Type**	No treatment is done and the waste is loaded into 20 liter bin.	To be disposed of at Pomona MSW dump.

	consisting of aluminum oxide, water, and polymers flows over the lenses.			

4.3. Coating

The coating has only one-unit process (Hadi et al., 2005). The plastic lenses are dipped in the mixture of water and 2.5kg of Sodium hydroxide (Caustic soda). The production line and waste generated during the process are indicated in Table 3.

Table 1. Lenses manufacturing process and waste generated

Process	Procedure	Waste Or Effluents And Characteristics	Treatment	Disposal
Coating	• The plastic lens is loaded into a coating machine. • A mixture of methanol, sodium hydroxide and Laka are prepared. • The lens is passed through the solution • The solution is recycled for a month	• Mixture of water, Laka, sodium hydroxide and methanol	• Neutralization with carbon dioxide through bubbling carbon dioxide through the mixture for a day before disposal	Disposed of in the drainage after neutralization with carbon dioxide.

5. Results and Analyses

5.1 Laboratory Analyses

All liquid effluent to be discharged into the public sewerage system must be done so with the written consent of the Environmental Management Authority (EMA) (Manga et al., 2008). The requirements for all liquid effluent discharge are spelt out in the Environmental Management Act (20:27) of 2003, under the Effluent discharge section.

The glass smoothing liquid, glass polishing liquid and the plastic polishing liquids samples were taken for laboratory analysis. The optometry waste was tested for pH, total suspended solids (TSS) and total dissolved solids (TDS). These parameters if not monitored and controlled, have a negative effect on the environment if unsafely disposed (Martin-Rios et al., 2018). The results obtained are shown in Table 4.

Table 4. Optometry Lab Waste Results and Analyses

Parameter	Glass Smoothing Liquid	Glass Polishing Liquid	Plastic Polishing Liquid
pH	11.80	11.05	4.70
TSS	330 g/L	220 g/L	310 g/L
TDS	0.80 g/L	17.10 g/L	10.10 g/L

5.2 Recommendations on pH

For all the liquids with pH higher than 8.5 neutralization with a mineral acid before discharge to the municipal stream such as dilute sulphuric acid is required (Mbeng et al., 2009). For pH less than 5.5 again neutralization with calcium hydroxide is advised. For high alkaline liquids it is important to neutralize with dilute sulphuric of concentration 0.01M.

5.3 Recommendations on TDS and TSS

The maximum limit of TDS and TSS is 0.3 g/L and 0.04 g/L respectively, so pre-treatment of all liquids before discharge is required. The TDS and TSS must be removed through pretreatment by filtration through the use of

bag filters that will capture the solids particles for later disposal. The solids (filtrate) can be stored in metal bins for further disposal by the City Council.

6. Environmental Management Plan for Optometry Waste

6.1 Byproducts

Generally, byproducts or waste from the manufacturing process include plastic/glass dust or fine shavings and a liquid polishing compound consisting of aluminum oxide, water, and polymers. The waste material is placed in metal bins for 48 hours along with sanitation compounds (vermiculite of cat litter) before disposal.

6.2 Environmental Management Plan

EMA regulations require that nearly all hazardous waste be treated prior to land disposal.

6.2.1 Training

Laboratory staff should be trained annually in hazardous waste management and emergency procedures relevant to their positions. Other staff may need to be trained in proper building evacuation procedures in the event of an emergency. The training must teach personnel to perform their duties in a way that ensures compliance with hazardous waste management regulations. Obviously, since hazardous waste management responsibilities differ for various staff, so do training requirements. EMA training regulations also require that hazardous waste generators maintain written job titles and descriptions for all employees with positions relating to hazardous waste management. Laboratory staff that pack hazardous waste for transport or prepare and/or sign manifests must be trained in accordingly. Also, OSHA's Lab Standard requires a plan, including training, addressing lab staff who works with chemical hazards.

6.2.2 Reporting and Record-keeping

Generators must generate a file (Notification of Hazardous Waste Activity) with EMA and obtain a certificate with an identification number. Generators should retain a copy of this form/receipt. In addition, generators must also retain weekly inspection logs for the accumulation area, data relating to hazardous waste determination, training records, job descriptions, hazardous waste manifests and notices.

The following elements of waste management program should be in place to reduce exposure to employees and the public:

i. Select the packaging material that is appropriate for the type of waste handled: Plastic bags/metal bins for solid waste, Bottles, flasks, or tanks for liquids.
ii. Use packaging that maintains its integrity during storage and transportation.
iii. Minimize storage time.
iv. Contact EMA to identify approved treatment disposal options.

7. Conclusion

Environmental compliance and adherence is critical for all key sustainable development projects. This paper focused on the waste management of waste generated from the optometry products manufacturing processes. Various solid and liquid wastes were generated from the cutting, polishing and smoothing processes. The solid waste generated was first pretreated and recommended for disposal at the local landfill in accordance to the EMA guidelines. The effluent generated was treated to accepted standards for disposal prior to which its physicochemical characteristics (pH, TSS and TDS) were determined using standard methods. The training of staff and record keeping are important aspects in environmental issues monitoring.

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