

An Investigation into the Radiological Waste Management of Selected Centers in Kano Metropolis, Nigeria

Mohammed Sidi, Chigozie Nwobi¹, Abdu Hamisu Dambatta²

Department of Medical Radiography, Bayero University Kano, Aminu Kano Teaching Hospital, Kano, Nigeria, ¹Department of Medical Radiography, College of Medical Sciences, University of Maiduguri, Borno State, Nigeria, ²Department of Radiology, Aminu Teaching Hospital/Bayero University, Kano, Nigeria

Correspondence: Dr. Mohammed Sidi, Department of Radiology, Aminu Kano Teaching Hospital, Kano, Nigeria.
E-mail: muhammadsidi82@gmail.com

ABSTRACT

Background: There is a need for every radiological facility to have an effective method of waste management for environmental protection and cost-effectiveness. Most of the waste produced by the facilities could be reclaimed and recycled for medical and industrial purposes. **Study Aim:** This study aims at investigating radiological waste management in some selected centers in Kano metropolis. **Materials and Methods:** The study design is descriptive in nature. Using purposive sampling method, eleven centers were selected. These are the hospitals and private centers that use automatic, manual, or both processing methods in their units. An unstructured interview was conducted with the technician in-charge of the various processor units. The audio-taped interview was converted to text notes for content analysis. The data were analyzed using standardized, open-ended content approach. Samples of spent solutions were analyzed for silver concentration using quantitative analysis. **Results:** Film processing units of radiological facilities in Kano metropolis drained their spent radiographic films processing solutions directly into general drainage system without being treated. The waste radiographic films and X-ray film packages were being discarded into dustbins. Quantitative analysis shows a high concentration of silver in the spent solutions; the average concentration of silver in spent developer, rinse, fixer, and wash solutions was found to be 1.4 mg/L, 0.9 mg/L, 5.2 g/L and 2.8 mg/L, respectively. **Conclusion:** There is no systematic system of waste disposal in Kano metropolis of Nigeria.

Key words: Investigation; Kano metropolis; radiological wastes management

Introduction

There is a need for every radiological facility to have an effective way of waste management for environmental protection and cost-effectiveness. Despite the current technological advancements in computed and digital radiography, the manual, auto, or both radiographic film processing methods are still in use in most of the radiological facilities in Kano metropolis. Radiographic film processing is the main source of waste in the radiological facility. The waste

stream associated with image processing consists of scrap film, spoiled chemicals, and wastewater containing chemicals and silver. In the course of radiographic film processing using the manual or automatic processing method, excess silver from the emulsion layer is released into the fixer solution with the silver concentration most frequently exceeding 5 g/L. ^[1] About 4.5 g/L of silver can also be recovered from wasted radiographic films. ^[2] Silver solution should be regulated as

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an environmental waste and discharged according to the approved city limits for silver. According to the European decision 2001 | 118 | EC (EEL, 47 | 2001), establishing the European wastes and hazardous wastes, imaging wastes are regarded as potentially hazardous wastes.^[1] The adverse effects of chronic exposure to silver are permanent bluish-gray discoloration of the skin (argyria) or eyes (argyrosis). Most cases of argyria and argyrosis have resulted primarily from exposure to the soluble forms of silver. Besides argyria and argyrosis, exposure to soluble silver compounds may produce other toxic effects, including liver and kidney damage, irritation of the eyes, skin, respiratory, and intestinal tract, and changes in blood cells.^[3]

The first reason why silver should be reclaimed from the spent film processing solution is because of its hazardous effect. Once silver is reclaimed from the solution, it is exempted from all hazardous waste regulations.^[1] The second reason for recovering silver from liquid photographic effluents is that it is a valuable commodity, and since there are effluents containing sufficient amount of silver, a cost-effective recovery could be implemented. Various methods of recovering silver (e.g., metallic replacement, electrolytic recovery) and a number of market equipment are available. Moreover, in some parts of the world, there is an organization responsible for collecting the effluents and recovering the silver from it. After selling the silver recovered from imaging wastes, the organization is obliged to credit 75% of the profit to the health unit and retain the remaining 25%.^[1] A study revealed that the amount of silver recovered per year from ten hospitals amounted to 140,527 U.S. \$ (about 116500 euros), part of which returned as income to the state.^[1]

Through the author clinical experience in one of the radiological facilities in Kano metropolis, silver solution is being discharged directly into the drainage system. This has a potential for environmental pollution and economic loss to the facility.

Materials and Methods

The aim of the study is to determine the practice of radiological waste management of selected centers in Kano metropolis. The study design is descriptive in nature. The study was conducted in Kano metropolitan area from January 2016 to March 2016. Using nonprobability purposive sampling method, study centers were selected; these include two federal government hospitals, seven state government hospitals, and two private radio-diagnostic centers, identified with numbers 1–11. These were centers with functioning X-ray equipment using automatic, manual, or both processing methods for radiographic film processing. All the hospitals and private radio-diagnostic centers without functioning X-ray equipment or with a functioning X-ray equipment but use either computed radiography or digital radiography were excluded from the study. Center 1 had

three processing units, two automatic and one manual; two manual processing units were surveyed each in Centers 2 and 3. The remaining centers each had one manual processing unit. In every center, the staff in charge of the darkroom was selected for the interview; it was assumed that this individual would possess the most accurate information regarding the centers' waste management system. Interview questions were open-ended. The informants were asked to answer questions to the best of their understanding. Informed consent was obtained from each informant. The communications between the researchers and informants were audio-taped. Questions asked during the interview include age, cadre, and working experience; the number of films used per month, volume of fixer and developer solutions used per month, how the rejected films were discarded, and how the spent fixer, developer, wash and rinse solutions were disposed of. The recorded information was then transcribed to text notes for analysis. A standardized, open-ended content analysis approach was used to analyze the obtained data.

In every processing unit, 2 ml each of fixer, developer, and washer solutions was collected and taken to the laboratory for analysis of silver concentration. For centers operating the manual processing system, sample of the rinse solution was also analyzed. The amount and cost of silver that could have been recovered from every processing unit were calculated from the concentration of the silver in fixer solution per volume of the fixer solution used in each processing unit. The fixer solution was used for the analysis; it is recognized to contain the highest concentration of silver among the solutions.

Results

A total of 15 darkroom attendants were interviewed from the government hospitals and private radio-diagnostic centers. They were males with a mean age of 42 years and standard deviation of 7.49 years. Their work experience ranged from 2 years to 23 years. The distribution of processing units is shown in Table 1. Center 1 generated 430 and 225 L of spent developer and fixer solutions per month from the three processing units. The silver concentrations in developer, rinse, fixer, and wash of processing unit A were 1.1 mg/L, 0.8 mg/L, 6.2, g/L and 3.0 mg/L. Units B and C were automatic processors and therefore had no rinse solutions. The concentrations were 0.8 mg/L, 5.0 g/L, and 1.8 mg/L for unit B and 0.6 mg/L, 5.0 g/L, and 1.5 mg/L for unit C. The amount of silver which might have been recovered from fixer solutions in Center A was 13.86 kg per year and with the current price of silver of 474 USD per kg. The management has been losing 6570 USD per year from the spent fixer solution. Center 2 produced 120 L each of developer and fixer solutions per month. The silver concentration of the developer, rinse, fixer, and wash in processing unit A were 0.9 mg/L, 1.4 mg/L, 5.3 g/L, and 2.6 mg/L and of the processing unit B were 0.6 mg/L, 0.8 mg/L, 4.9 g/L, and 2.4 mg/L. The quantity of

Table 1: How spent radiographic film processing solutions are being managed in Kano metropolis

Hospital/ Center	Number of processing units	Average number of films per month	Average volume of developer per month	Average volume of fixer per month	How developer, fixer, and washer are discarded	How wasted films are discarded
1	A	600	30	25	Direct to drainage	Into dustbin
	B	1260	200	100	Direct to drainage	Into dustbin
	C	1200	200	100	Direct to drainage	Keep in jackets
2	A	1480	80	80	Direct to drainage	Keep in jackets
	B	520	40	40	Direct to drainage	Keep in jackets
3	A	1800	1000	80	Direct to drainage	Into dustbin
	B	600	25	25	Direct to drainage	Into dustbin
4	A	600	25	25	Direct to drainage	Into dustbin
5	A	720	30	30	Direct to drainage	Into dustbin
6	A	1000	30	30	Direct to drainage	Into dustbin
7	A	490	20	20	Direct to drainage	Into dustbin
8	A	600	40	40	Direct to drainage	Into dustbin
9	A	300	20	20	Direct to drainage	Into dustbin
10	A	168	10	10	Direct to drainage	Into dustbin
11	A	252	10	10	Direct to drainage	Into dustbin

silver lost through the fixer solution in Center 2 was 7.440 kg per year which cost 3527 USD per year. Centers 3–9 which were hospitals from the state government generate 1190 L of developer solution and 270 L of fixer solution. The mean silver concentrations of the spent solutions in the seven hospitals were 1.9 mg/L, 1.0 mg/L, 5.1 g/L, and 3.4 mg/L. The hospitals lost 17.63 kg of silver per year; hence, the state health management has been losing 8356.62 USD per annum. Center 10 generated 10 L each per month of developer and fixer solutions and the concentrations of the spent were 0.8 mg/L, 0.4 mg/L, 5 g/L, and 1.4 mg/L. The center lost 0.60 kg per year which cost 284 USD. While Center 11 produced 10 L each of developer and fixer solutions per month and the concentrations of silver were 1.0 mg/L, 0.8 mg/L 5.5 g/L, and 1.9 mg/L. It lost 0.66 kg per year with an estimated cost of 313 USD. In the entire selected centers, the spent radiographic film processing solution was drained into general drainage system without any treatment and wasted X-ray films were discarded into the dustbins.

Discussion

The findings of the current study as shown in Table 1 show that all the radiographic processor units in the selected centers drained the fixer, developer, rinse, and wash solutions directly into drainage system in Kano metropolis. All the spent processing solutions produced from the processor units in Kano metropolis contained silver exceeding internationally approved limits for direct discharge into the drainage system as shown by quantitative analysis of the solutions in Table 2. Once the concentration of silver in spent radiographic film solution exceeds 0.5 mg/L, it should not be discharged directly into the drainage system.^[4] Therefore, radiological facilities in Kano metropolis are sources of significant environmental pollution by discharging these solutions into the drainage

system without treatment. Discharging hazardous chemicals to the general drainage system will affect the environment and the members of the public more, especially those in direct contact with the chemicals without protective instruments. In the entire centers, the waste radiographic films were discarded into dustbin as shown in Table I, finally ending up at the general refuse site of the hospitals and centers. The solid silver in the waste radiographic films is a pollutant to the environment. The management loses a lot of money from the silver and plastics that might have been recovered from the waste radiographic films. The current study is in accordance with the findings of Sanida *et al.*,^[1] which show that the management of radiological facilities lose a lot of money due to poor management of radiological wastes. Their findings show significant contribution of radiological facilities to environmental pollution because the spent radiographic film processing solutions are drained into general drainage system without any treatment. The findings of the current study went contrary to the study conducted by Amorim and Bauer,^[5] which shows that only 43% affirmed that they threw the solution directly through the sink, 36% diluted the fixer in water and threw it into the sink, 14% used a specialized company to discard it, and 7% used other means. The developer was discarded as follows: 42% threw it down the sink, 36% diluted it in water before throwing it into the sink, 13% used a specialized company to discard it, and 9% used other ways. With respect to the disposal of radiographic films, 51% threw them into the trash and 49% used a specialized disposal company. Another study conducted by Grigoletto *et al.*^[6] shows that 16.66% of the health-care centers discharge their developer solution directly into the drainage system, fixer by 8.33%, and film washing water by 75% of the centers. This was not in accordance with the current study which revealed that all the selected centers drained their spent solutions directly into the drainage system. The findings

Table 2: Silver concentration in spent radiographic film processing solutions

Hospital/Center	Processing unit	Developer concentration (mg/L)	Rinse concentration (mg/L)	Fixer concentration (g/L)	Wash concentration (mg/L)	Kg of silver (fixer/year)
1	A	1.1	0.8	6.2	3.0	1.860
	B	0.8	-	5.0	1.8	6.000
	C	0.6	-	5.0	1.5	6.000
2	A	0.9	1.4	5.3	2.6	5.088
	B	0.6	0.8	4.9	2.4	2.352
3	A	2.5	1.0	6.0	6.0	5.760
	B	1.0	0.9	4.8	2.0	1.440
4	A	1.2	0.7	5.2	2.0	1.560
5	A	2.8	1.2	5.0	4.0	1.800
6	A	3.0	1.5	6.0	6.7	2.412
7	A	1.4	0.9	4.0	1.8	0.960
8	A	2.0	1.0	5.4	2.9	2.592
9	A	0.9	0.6	4.6	2.0	1.104
10	A	0.8	0.4	5.0	1.4	0.600
11	A	1.0	0.8	5.5	1.9	0.660

of the study conducted by Carlson^[7] are in agreement with the current study which observed that chemical residues such as developer, fixer solutions, and xylene leftovers were inappropriately stored in the place where they were generated and were later taken into the basement of the building, where they were left under unsafe conditions, in an unventilated area, without containment means, and over permeable floor.

For the spent developer solution, image service or technician should wear personal protection equipment, such as glasses and gloves. The solution should then be diluted with equal volume of water and drained into the drainage system.^[8] Drain service contract should be coordinated to ensure drains are regularly cleaned out twice per year.^[8]

For the spent fixer solution, the image service or technician using personal protection equipment should collect the used solution in a plastic container, and the container should have a tight-fitting cap that remains closed at all times, except when adding the fixer and be well labeled. When the container is 90% filled, it should be carried away from the processing unit by a trained technician for on-site or off-site silver recovery.

The plastic base and its content of silver must be stored in properly labeled secondary containers which will finally be carried away by appropriately-trained technicians.

The internationally accepted method of silver removal from the fixer solution is by either electrolysis or metallic replacement. If the facility is large, it should have an on-site silver recovery unit. The unit uses an instrument to remove the dissolved silver from the fixer solution. Once the silver has been removed, the solution is no more hazardous and can be drained into the general drainage system. If the facility does

not have on-site silver recovery unit, it is mandatory to look for off-site silver recovery unit that will collect the fixer and recover silver from it. This can either be a company or another facility that has a silver recovery unit.

Conclusion

Radiological facilities in Kano metropolis contribute to environmental pollution through a lack of standardized and poor methods of radiological waste management while losing significant source of potential economic benefit from silver recovery.

Recommendations

1. The managements of federal and state government hospitals should endeavor to have silver recovery units
2. They should also have a mean of reclaiming and recycling the important components of the discarded X-ray films
3. The solid lead from X-ray films packages should be separated for recycling by appropriate authorities
4. Technicians' in-charge of the processing units should receive training on proper disposal of spent solutions.

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Conflicts of interest

There are no conflicts of interest.

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