

Health implications of generated effluents in a metallurgical industry

Abstract

Effluents are liquid wastes that are discharged from sewage systems, factories, nuclear power stations, or other industrial plants, which include a metallurgical industry like the Ajaokuta Steel Company Limited. The is an integrated Iron and Steel Company that is saddled to produce steel from the scratch using the Blast Furnace –Basic Oxygen Technology en-route to steel making process where different grades of steel could be produced. The steel company uses large quantities of water for processing various products and therefore tends to cause effluent when disposed into the River Niger. In the metallurgical industry, water is used in the production process, which could serve as a coolant to cool the machines, equipment, system, and pipelines. In these processes, a lot of generated effluents are disposed of from the channels. This work, therefore, focuses on the generated effluents, their effects on public health, safety, and the surrounding environments, which could harm living organisms like humans, animals, and plants. Some findings and policies surrounding the effective management of effluents were discussed; procedures for achieving the reduction of effluents at the source and some derivable benefits from preventing the effluents are discussed. Conclusions were given to assist all the stakeholders and the management of the Company and other metallurgical industries to handle generated effluents and to adopt best practice in managing them without causing health hazard and challenges to the industries and their surrounding environments to prevent, collect and proffering solution that will curb or reduce the generation of effluents within and the surrounding of the industrial areas.

Keywords: effluents, effects, generated, surrounding, environments, health

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Introduction

The Ajaokuta Steel Company Limited is an integrated steel plant established for the production of liquid steel from the operations of the Blast furnace en route to the steel making process. The process consists of the installation of the Basic Oxygen Furnace at the steelmaking shop where various grades of steel could be produced. These processes have to do with the demand at a particular time. The company has the rolling mill, which consists of four rolling mills where different roll products. The engineering works, where the concentration of other shops like the foundry and pattern making, the machine and repair Shop, the forge and fabrication shop and the power equipment Shop and well over fifty shops situated in the steel plant. During these production processes, a lot of water is used as a coolant on the products during manufacturing, while some scales are also removed from the products thereby generating effluents from such production processes. The characteristic of recent technological manufacturing procedure contributes to producing a large number of various kinds of waste materials, which are; differ in their chemical composition and physical properties concerning the quantities generated and their conquest effects on the industrial and immediate surroundings. It arguably verified that some other companies or industries could utilize some of this waste as they take off manufacturing materials for further processing. When the generated effluents are disposed of, the remaining ones should be controlled in such a way that they will no longer pose a threat to the safety of humans and their immediate surroundings. One type of spot contamination is the discharge of effluent. Heavy metals, arsenic, raw water, bacterial coli, and several disease-causing protozoans are pollutants found in effluent discharge. In bottom sediments, these toxins accumulate and become absorbed

into bottom-dwelling fish and invertebrates. The pollutants travel rapidly through the food chain until they are absorbed into living plants and livestock, affecting the health of animals and humans. Sewage effluents at the Steel Company are divided into three main groups :- (a) Non- contaminated industrial effluents, which include effluent from the Turbo Power Plant (TPP), chemical water treatment plant for equipment cooling, and small quantities of other industrial sewage. Effluents from Turbo Power Plant and chemical water treatment plant contain Sulphates and Chlorides. (b) Contaminated industrial effluents include sewage from the Engineering Workshop, Carbonic Acid shop, Laboratories, the Rolling mills' processes, and other facilities. (c) Industrial (Phenol) effluents of the Coke –Oven and by-product, the blast furnace and steel making processes as these are subjected to biochemical treatment on the site and could only affect those to be discharged into plant sanitary networks. Condensate accumulated in the gas pipeline traps are transported to the phenol sewage of the Coke –Oven and by-product plant and are exported to the sewage treatment facilities. Phenol effluents after purification will have the following characteristic Viz. Phenol- 5mg/l, Thiocyanide 10mg/l, Cyanide 3mg/l, Oil 25mg/l and Biochemical Oxygen 30m.¹

Experiential procedure

The experiments were conducted at the Ajaokuta Steel Company Limited, the samples were collected from various shops and these generated effluents were subjected to laboratory procedures to determine their level of health implications to the metallurgical industry and their immediate surrounding and environment. The experiments were performed at the express laboratory of the company; necessary laboratory procedures were strictly followed. The results

obtained show that the generated effluents have some health impact on the environment. The generated effluents were collected at various points and locations which include the industrial environments, water within and around the industrials surrounding, the soil, plant animals, and the human that are living or working in and around the industrial environments.

Method and equipment: production processes at the Ajaokuta steel company limited

The Steel plant was designed to produce 1.3 million metric tonnes of liquid steel per annum; the plant is an integrated one where raw materials are processed from the primary units. These raw materials

generate effluents during the production processes. Figure 1 gives the production processes of the steel plant from the primary units to the finished or products, while Figure 2- Figure 5 show the operational processes of some selected shops. Figure 2 shows the production of coils at the Wire Rod Mill, during the production process water was used to cool most of the machines and equipment that are located underground. A similar trend is also required in the operation of the Light Section Mill where rods of various sizes are produced. Figure 4 shows the chemical water treatment plant where the production of demineralized water for Boilers & Turbines is been carried out and Figure 5 shows the casting processes in the foundry and pattern making shop. Many other shops use water for their production processes in the course of that many effluents are generated.

AJAOKUTA SteelPlant Process Chart

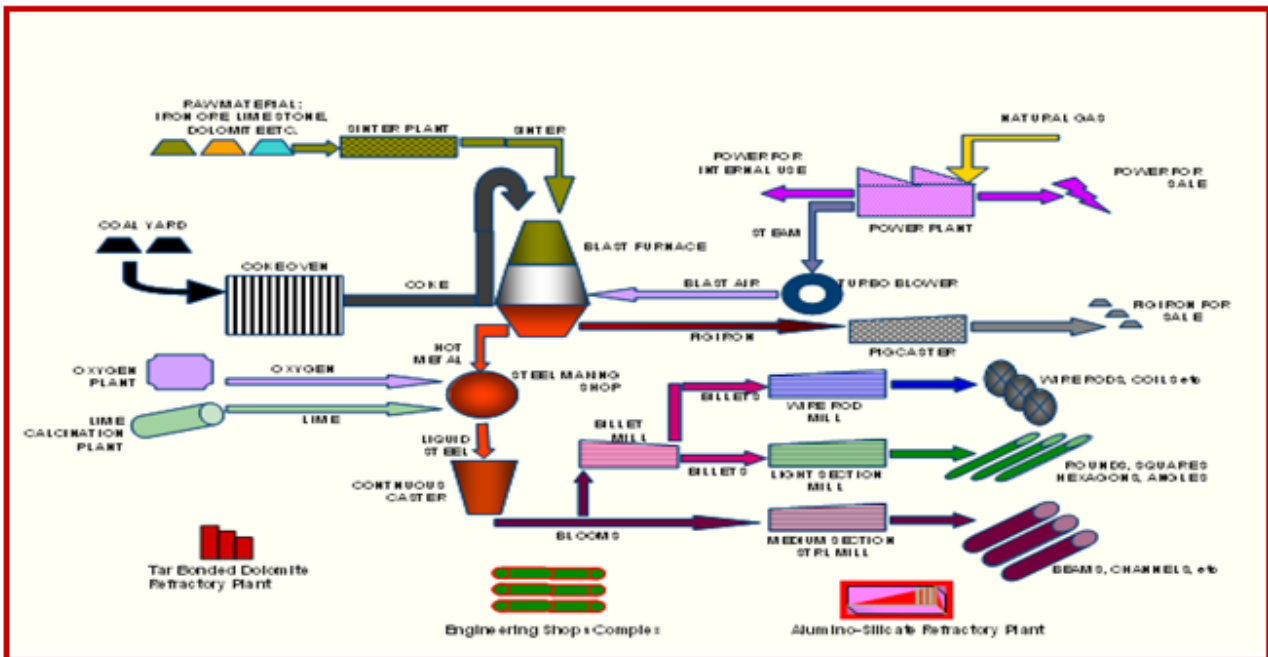


Figure 1 Show the production processes at the Ajaokuta steel plant.

Wire Rod Mill



Figure 2 Shows the production process of coils rods at the wire rod mill.

Light Section Mill In Operation



Figure 3 Shows the production process of rods at the light section mill.

Chemical Water Treatment Plant



Figure 4 Production of demineralized water for boilers & turbines.

Foundry & Pattern Shop



Figure 5 Casting process at the foundry and pattern making shop.

Methods

The samples of the generated effluents are taken from various shops that are producing different kinds of products ranging from chemicals, steel products, machining, cast products, and other products that are available in an integrated steel plant. These generated effluents were analyzed because they have impacts on the surrounding and are capable of negatively affecting the industrial environments and the surrounding.

Impact of effluents on the surroundings

Industrial effluents

The use of industrial charging quantities and additional metals, fuels, oxygen, energy, and water is associated with the organization of the castings of either steel or cast iron products. Apart from the final cast materials, slag, exhaust gases, vapor from cooling systems, and melting dust are the materials of castings. Consumption of industrial charging quantities and additional metals, fuels, oxygen, energy, and water is associated with the organization of castings of either steel or cast iron products. The products of castings, aside from the final cast products, are Slag, exhaust gases, cooling system vapor, and melting dust. In general, the term industrial effluent protects all types

of industrial waste materials, gaseous, liquid, and solid. In a narrower context, industrial effluent flows into streams or rivers because of industrial processes and activity.¹

Action of effluents on water

History made us know that no civilization ever arises without an adequate water supply. The Ajaokuta Steel Company Limited was sited around the perennial river of the Niger. The presence of effluent on the water can cause a lot of challenges and health hazards, which will further culminate in diseases and illnesses, otherwise called water-borne diseases. Such as Typhoid fever, Dysentery, Cholera, etc., which, are related to the presence of effluent in water, lack of potable water supply, and poor method of wastewater disposal otherwise, called sanitations² We all desire a good water supply to decrease our mortality rate but care less about its proper disposal.³ Water is required for domestic and industrial uses, as much as we know drinking water is used for general purposes, for production processes of minor consumers, for air-conditioning, and indoor and fire – fighting services.⁴ The estimated total consumption rate of drinking water is 6,700m³/day, which includes 1,850m³/day. These are required for several purposes including drinking and sanitary purposes. Provisions are made for a common low-pressure system of general-purpose and firefighting water supply, incorporating closed –circuits networks and equipped with fire hydrants.⁵ To meet the plant's maximum requirements for potable water during peak hours and cover the firefighting needs, provisions are made for the off-site facilities. This facility incorporates water storage tanks that reserve a total volume of 6,000m³ of potable water to be disturbed uninterruptedly to every consumer of the Steel Plant.⁵ The presence of effluents will make it very impossible to achieve all the above-mentioned objectives for which the supply of water is needed.⁶ While people intuitively link filth of illness,⁷ the introduction of disease⁷ by pathogenic organisms into contaminated water.⁷ Not until the middle of the nineteenth century that such an assertion was, recognized.⁸ Sanitary sewage and industrial untreated water were supplied to the inlet chamber through two delivery pipelines. These were passed through the grates, sand traps, primary settling tanks, and reservoirs. Later, gravitational pressure pipelines dispose of the clarified sewage disposed back to the River. Effluents are disinfected with chlorine in contact reservoirs. From sand traps, and are transferred into the sand bins utilizing hydraulic elevators from where they were carted away by Motor Vehicle trucks.⁸

Wet sediments from primary settling tanks and excessive active slit from secondary settling tanks are transferred into Aerobic mineralizers by airlifts. A stabilized mixture of sediment and the excessive active slit was pumped out from aerobic mineralizers to slit areas by a pump installed at the industrial building. Sewage treatment facilities are intended for complete biological treatment of sanitary and untreated industrial water coming from the steel plant territory before their discharge to Niger River.⁸ The treatment of the final waste was free from being toxic and meets the drinking water norms before discharging them into the river. Otherwise, the aquatic life of the flora and fauna of this important river will be gradually endangered the lives of people and animals. It also conforms to the standard of the Federal Environmental Protection Agency on environmental pollution. If sewages from the steel are not properly treated before they are discharged into the Niger River, this could lead to people contracting diseases. Effluent can have some harmful effects on those who drink contaminated water due to the transmission of bacterial and viral waterborne diseases that will endanger human health.⁹

Action of effluents on soil

The principal direction in the water resources pollution control is the development of the re-circulating water supply systems, without discharge of the effluents into the water basin. Seven re-circulating industrial water supply cycles are arranged at the Steel Plant. To improve the Steel Plant water supply system aimed at prevention of the water basin pollution and provision of the rational use of the water resources the followings are proposed: to develop and introduce a catchment system for the rainwater, drainage and flushing water catchment from the Plant territory with use for the replenishment of the re-circulating cycles due to which the fresh water intake from the river Niger will be reduced; to implement a system for stabilizing treatment of the make-up water to prevent fouling of the re-circulating water supply system; to introduce the technically justified norms and rates of water consumption; to establish water protection zones to prevent contamination and choking-up of rivers and reservoirs, and to exclude the possibility of accidental discharges into the rainwater drainage.⁹ The manufacturing processes at the industries consist of solid waste disposition containing organic matter. In most cases, such depositions contain contaminants such as heavy metals that have effects on the ecosystem.¹⁰

Action of effluents on plant

Effluents are categorized as a point source or non-point source; all wet effluents entering watercourses via pipes or channels are identified as the former. Although the drainage of storms can enter watercourses through pipes or channels, non-point effluents are considered. The presence of effluent in the plant consists primarily because of metallurgical processing processes from different stores, inorganic material washed into a drain. The presence of effluent in plants will not allow some elements like nitrogen and phosphorus. When caused by industrial effluent heating or anthropogenic (human).¹⁰ Changes in the vegetation of the Streambank that raises stream temperatures from the manufacturing process. It is possible to identify heat as a water pollutant.¹⁰ Heated discharges can significantly modify the ecology of a lake or stream. Heated effluent since the solubility of in water, gas is inversely proportional to temperature, decreasing oxygen solubility in water; the amount of dissolved oxygen available to aerobic (oxygen-dependent) organisms is reduced. Heat also increases aquatic organisms' metabolic rate (unless the temperature of the water gets too high and kills the organism), which also decreases the amount of dissolved oxygen as breathing increases.¹¹

Action of effluents on animals

The cumulative population of this direct flow into surface waters is equal to around two billion. Usually, effluents are rich in nutrients (phosphorus and nitrogen), biodegradable organic carbon, residues of pesticides, and fecal coliform bacteria (bacteria that normally reside in warm-blooded animals' intestinal tract, suggesting contamination by animal waste). Owing to the level of fertilizer and pesticide use, both surface and groundwater contamination is prevalent in agricultural regions.¹¹

Effluent influence in humans

The operation of a liquid waste treatment facility to safeguard public health from disease vectors is required by federal regulations.¹² All routes by which infection¹² is transmitted to humans¹² are sickness vectors (birds, rodents, bees, and mosquitoes are good examples). This¹² defense must be done¹² by¹² limiting the supply of food for the vectors.¹² It is an efficient¹² way of managing vectors, in particular

rodents.¹² It is important to add cover material at the¹² end of¹² each day of service in landfills. Other techniques are toxins, repellents, and natural monitoring, including predator availability.¹³ Treating effluents with pathogen reduction processes, (sewage sludge) helps to monitor the spread of diseases.¹³ Effluents should not serve as a nuisance to people living within the steel company because of their adverse effects. A more dignified way of disposing of effluents can remove the source of cholera pathogen, and the outbreak will remove even waterborne diseases caused by effluent that has become a major concern. All aspects of civilized life, including food, climate, hazardous materials, noise, and other environmental issues, are not just water¹⁴ today's public health challenges. The environmentalist's work is more difficult by the current propensity to assign many illnesses to environmental origins, including psychological stress; whether or not there is any proof that ties causes and effects of inappropriate effluents, which are disposed of by the industry. The environmentalist faces the very difficult task of explaining some details about the causes and effects often associated with environmental contaminants, including effluents, as they respond over years and decades to human health and the climate.

Method of effluents discharging channel

Sludge pond located outside the plant territory along Niger Bridge Estate receives effluent from the Turbo Power Plant (TPP), Chemical Water Treatment Plant, Coke-Oven and By-Product Plant, Foundry and Refractory shops. The total flow rate of effluent evacuated to the sludge pond will be 1,855M³/day.¹⁵ After clarification in the sludge pond, the settled water is recycled for further usage in the plant network for re-use. Metal-bearing effluent from the steel, iron making plants and from contaminated re-circulating cycles of the raw materials preparation plant are forced in to pump house to the dehydration plant located in the Sintering plant area. Clarified water from the sludge thickeners is recycled to the Converter and Blast Furnace gas cleaning plants and the re-circulating water cycle of the raw materials preparation plant.

Application of effluents

Effluents are used in urban and industrial pumps and ranchers use several methods of management to preserve groundwater, including the use of more reliable plumbing to reduce leakage and improvements in agricultural Methods for using less water for irrigation. To preserve high-quality surface and groundwater supplies, lower quality streams, such as effluent, used by other organizations where possible.¹⁶

Result and discussion

Effects of produced effluents and heavy metals on its environments

Similar warnings were given by many states in the United States that have theoretically released about¹⁷ harmful levels of mercury or other bio-accumulated toxins in freshwater and Fishponds. Arsenic, silver, lead, and cadmium are deposited as well¹⁷ in lakes and streams from the air near emitting facilities. These chemicals are applied to rivers from runoff from slag piles and industrial effluent.¹⁸ In a variety of heavy metal parts,¹⁸ effluent electroplating is used. Heavy metals, in particular, copper are detrimental to marine life and harmful to human health. A large number of cases of surface water pollution by toxic and carcinogenic organic compounds have occurred in the past quarter-century.¹⁸ Lead causes decreased mental capacity, weakness (especially hand) numbness of hands and feet, headache, abdominal cramps, diarrhea, abdominal pain resembling symptom and anemia,

each heavy metal has its characteristic symptom cluster. Lead also can affect the blood-forming mechanism, kidneys, and hearts long-term effects vary, Lead exposure causes irreversible brain damage. Cadmium causes chronic lung disorders as human carcinogens chromium, beryllium and cadmium have been involved. (Any cancer-producing substance).¹⁸ It should be noted that when heavy metals are present in the effluents produced, they can cause health risks, such as vomiting, abdominal pain, painful and profuse diarrhea, shock, coma, seizures, and death; discomfort, inflammation, mucous membrane, and ulceration of the skin; kidney damage. In chronic stages: fatigue, loss of energy, disruption, nasal septum perforation, ulceration of the skin fold, increased pigmentation of the skin, exfoliative dermatitis, rashes, muscle paralysis.¹⁹

Effluent pollution on river -Niger

In most nations, several eco-technologies deployed follow a remarkable political breakthrough that is coming to full fruition. There was growing fear by the mid-1970s that certain rivers were dying from industrial waste and the like. Both fishing and tourism were in steep decline. The concern is how to solve these problems created by the generation of effluent pollution in the river, where most of the aquatic animals are killed through the contamination of the substances. In the situation of the Ajaokuta Steel Company Limited, the effluents generated are disposed of properly without allowing them to be discharged into River Niger. The reason is the danger that the effect may pose on humans, plants, animals, and the environment. Proactive measures are put in place to tackle these common problems with common solutions. The river within this surrounding is protected against pollution and its associated protocols. Make proper arrangements in securing and protecting humans, animals, and plants from contamination. Adopt acceptable and proper methods in fashioning out a Clean-Up Plan in and around the river.²⁰ Before discharging the generated effluents into the Niger River, the management of the Steel Company should treat the effluent (sewage), minimize industrial contamination, and make the river safe for other useful activities such as swimming, fishing, and other related activities. The improper treatment of effluents before discharging them can result in widespread pollution problems therefore hampering the health of the residents and their environments. The challenges of the effluents may be devastating to the health of those that are consuming water within these locations. People living along / around the Ajaokuta villages like Geregu, Itobe, and Lokoja, and other environs are expected to observe every precautionary measure as regards public health and safety. Effluent can contribute to about 90 percent of all diseases that can kill a handful of people because of the pollution.²¹

Summary of results

The research findings were able to show that the management and the workers in the industry have to do everything possible to put in measures that will assist them in reducing the generation of effluent to the nearest minimum level. These can be achieved by the company engaging in some designed measures: (i) the Ajaokuta Steel Company Limited generates a lot of effluents due to its nature of operations and a policy should be put in place to reduce its effects on the immediate surroundings, thereby eliminating its effect and impact on river Niger. (ii) the Ajaokuta Steel Company Limited can put the necessary parameters and measure to curb or eliminate the hazardous effects of effluents on the industrial environments and its immediate surroundings for the protection of public health; (iii) Reducing the source is radically different and more desirable than handling waste and reducing emissions. The firm needs to fix the historical lack of

commitment to source reduction; (iv) Reducing sources is inherently different and more desirable than reducing waste handling and emissions. The company must resolve the historic lack of commitment to the reduction of the source. (v) It is necessary to avoid effluents by reducing the source²¹ to protect human lives from diseases such as kidney damage, infants and children; delays in physical or mental growth, and high blood pressure and have an effect on the surrounding environment.

Policy

Wherever possible, effluents should be avoided or minimized at the source; effluents that cannot be avoided should be recycled in an environmentally friendly manner and disposed of or other released into the atmosphere be only used as a last resort and should be carried out in an environmentally safe manner.²¹ The conscientious implementation of avoidance of effluents, including all the influences and practices and their costs, resulted in higher profitability rather than a net cost for the organization and its surrounding environments as a whole. Customers, regulators, and the community are required to relay this message to environmental engineers, environmental scientists, and everyone else in the field of environmental protection.

Steps of reducing effluents

The Management of the Ajaokuta Steel Company Limited could also adopt these steps in reducing generated effluents right from the production processes. The steps to be adopted are represented in Figure 6 which describes how to minimize effluents, The steps are further divided into six categories : (i) Adopting the principle of effluents reduction (ii) Planning and organizing the evacuation of the generated effluents (iii) Organization of assessment and commitment proceed (iv) Effluents audit (v) Feasibility Analysis and (vi) Implementation.

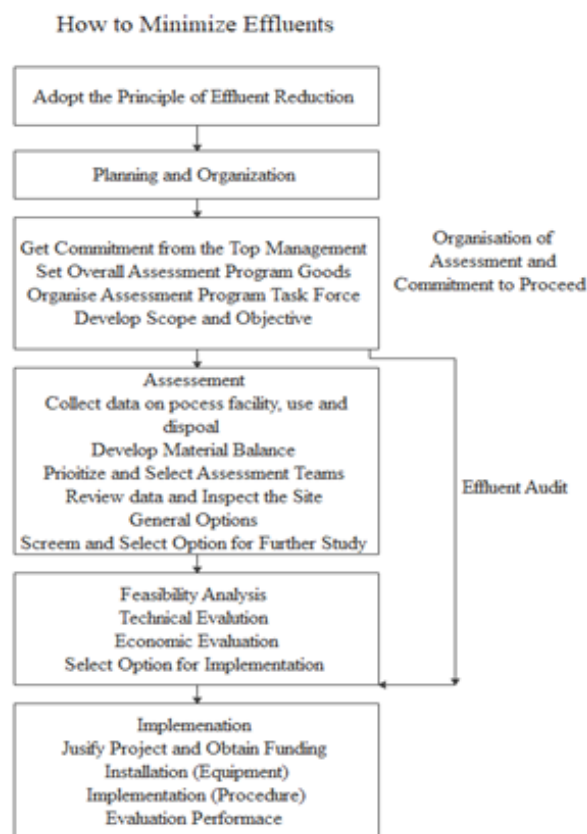


Figure 6 Procedure to access and implement source reduction.

Staff or top management may initiate the planning and organizational stage, whatever the case, securing the unambiguous dedication and encouragement of top management is the first prerequisite. The critical consequence of the planning and organizational processes are clear. The extent and coherent collection of effluent minimization or source reduction program objectives. The assessment phase can start only after the Appraisal Software Task Force has completed the organization of the phase itself and has obtained an unequivocal agreement to proceed. The assessment program and the corresponding phase, 'feasibility review,' follow the previously described general procedure for an effluent audit. The product of the effluent audit is a final report presenting the facts, data, and results of the effluent audit procedure. The execution of the choice of options ultimately agreed upon must require a thorough and accurate performance evaluation. An efficient cost accounting system must be in place for this method of achieving valuable results.

Derivable advantages of cubing or eliminating of generated effluents

In the process of securing and making public health sound and prevented from unnecessary health issues and challenges. There are needs to cub or eliminate generated effluents in metallurgical industries which consists of over fifty (50) Shops/units for the production processes and manufacturing of various engineering products for the use of the populace.

- I. The generated effluents can be carefully disposed of, to protect the life of the workers and the immiserate surrounding from having serious health issues.²¹
- II. The process will also assist in the preservation of the environments, which include the aquatic life, keeping the surrounding in an eco-friendly situation to prevent the climate change syndrome; these processes will also improve the relationship between the company and those who transact business with them.
- III. Maintaining of consistency principle of environmental friendliness can enhance the company's profile.
- IV. These steps will cumulate to efficiency and effectiveness for a greater manufacturing boom.
- V. If the generated effluents are properly managed at the production of process levels it will translate to managing financial implication which could be incurred if solving the issues or challenges that could have arisen from poor disposal handling.

Conclusion

Ajaokuta Steel Company Limited was established to not only manufacture high-quality goods, provide jobs for young people in society but also to work effectively to eliminate or reduce unnecessary by-products simply because they have little or no market value and add cost to production. If manufacturing costs are higher, so profit margins are smaller. This is the basis of modern-day pollution reduction and waste minimization activities. Managing of generated effluents is therefore important, as these will reduce the level of contacting heavy metals and their hazardous effect on the plants and their surrounding environments. The primary aim is to create water of high quality by eliminating or destroying as many pollutants as effluents that may be harmful to humans and their environments. Without producing wasteful by-products such as effluent and sludge,

which are most often in large quantities, the company cannot produce high-quality products.

Effluent management processes are essentially emission control methods, whether applied to industrial or municipal applications, which does not mean that pollution reduction practices are not suitable for the treatment of waste in an industrial company. However, understand that we cannot eliminate the wasteful byproduct of effluents as one might try but this could be achieved, do if a good mechanism is put in place (treatment facility), and identify another technology to make our products and eliminate excess effluents from the production process by treating them. Generated effluents from many sources are caused due to the nature of the type of production processes in various shops of the steel company. As we have seen with heavy metal and toxicology of some elements like lead, copper, and iron, etc. of their effects on plants, animals, and the human and the environments including contamination in fishes, environmental pollution that could arise from the widespread and lasting consequences. Finally, the management of the steel company must adopt best practices to see that they have control over the effluents produced through the processes involved in the metallurgical industry.

Suggestions and recommendation

The principal direction of managing generated effluents in the metallurgical industry should be by adopting best practices. Water resources pollution control is the development of re-circulating generated effluents, without discharging them into the water basin. To improve the steel plant surrounding environments and reduce the effect of generated effluents the following recommendations and suggested:

- A. That the management of the steel company should develop and introduce a catchment system for the rainwater, drainage and flushing water catchment from the plant territory with use for the replenishment of the re-circulating cycles due to which the freshwater intake from river Niger.
- B. That the management should consider implementing a system for stabilizing treatment of the make-up water to prevent fouling of the re-circulating water supply system.
- C. A technically justified norm and the rate of water consumption should be introduced for effective discharge of effluents.
- D. The management should establish water protection zones to prevent contamination and choking-up of rivers and reservoirs.
- E. Proper measures and quality control checks must be put in place to exclude the possibility of accidental discharges into the rainwater drainage.
- F. The unused part of waste – sludge and the industrial refuse should be removed into a specially arranged outlet as specified in the Detailed Project Report on industrial sludge pond and disposal.
- G. The production process should be monitored thoroughly to reduce waste generation due to the improvement of the technological processes.
- H. The management should consider a better way of recycling generated effluents and return to the process.
- I. There should be harmony and cooperation with the other shops within the steel company for the safe management of generated effluents.

- J. An effluent prevention program must be implemented in the manufacturing companies for the protection and preservation of public health.
- K. The complete process of discharging generated effluents from the industries must be properly planned and organized. This must have an encompassing policy for the prevention and protection of public health and short of this will not be in the benefits. Any initiative as far-reaching and all-inclusive as effluent prevention of raw materials, machinery, waste, and goods must have the enthusiastic, active support of the company's top managers to succeed.

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None.

Conflicts of interest

The authors declare that there is no conflict of interest.

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