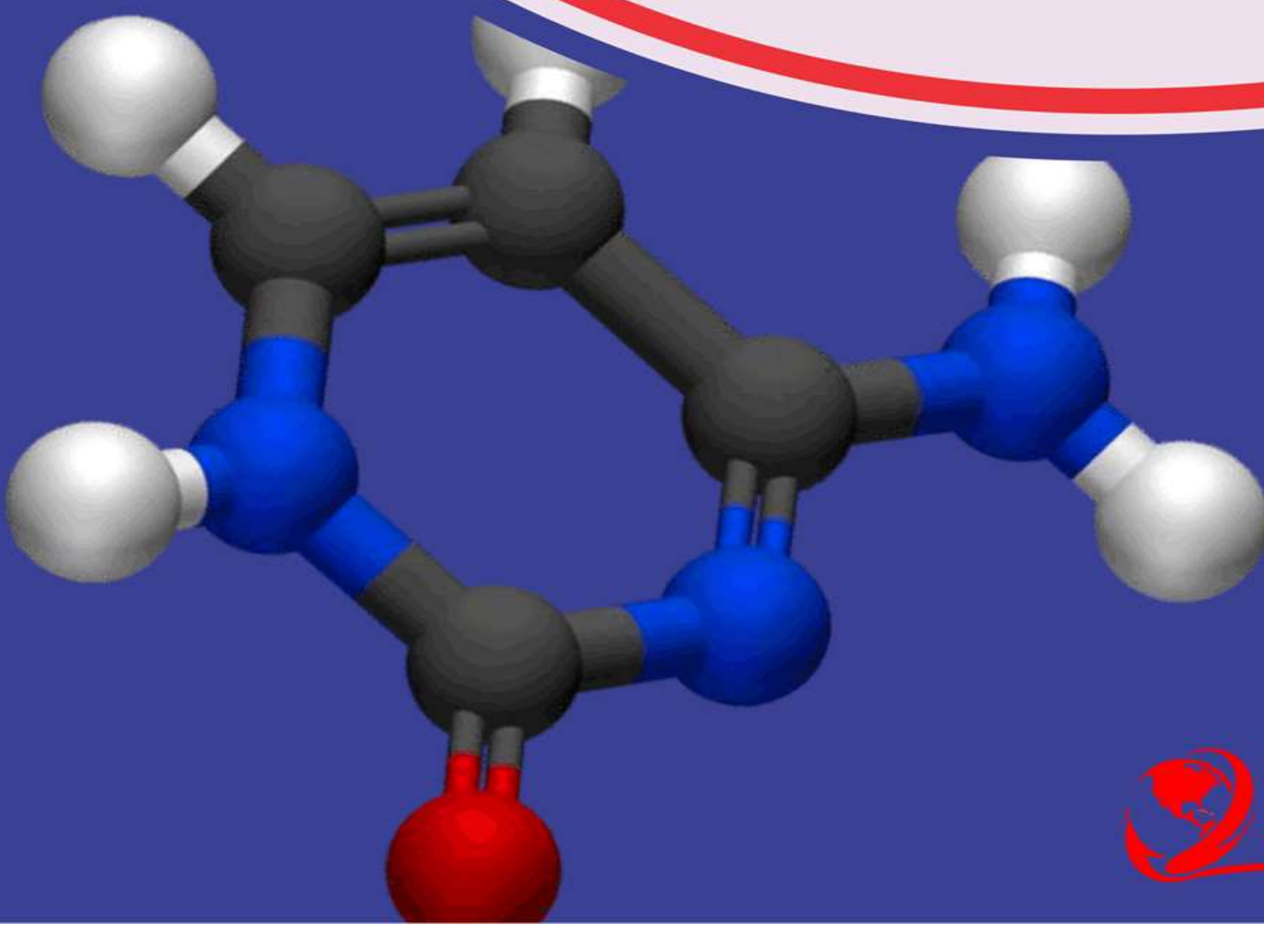
American Journal of
Physical Science
(AJPS)

INDUSTRIAL AND COMMUNITY WASTE MANAGEMENT: GLOBAL PERSPECTIVE

Awuchi, Chinaza Godswill, Awuchi, Chibueze Gospel, Amagwula, Ikechukwu Otuosorochi, and Igwe, Victory Somtochukwu



African Journal of Physical Sciences

Vol. 1, Issue 1, No. 1, pp 1 - 16, 2023 www.iprjb.org

Industrial and Community Waste Management: Global Perspective

[1*]Awuchi, Chinaza Godswill

Department of Physical Sciences, Kampala International University, Kampala, Uganda

[*]Corresponding Author's Email: awuchichinaza@gmail.com and awuchi.chinaza@kiu.ac.ug

[2]Awuchi, Chibueze Gospel

Department of Environmental Management, Federal University of Technology Owerri, Imo State, Nigeria

[3]Amagwula, Ikechukwu Otuosorochi

Department of Food Science and Technology, Federal University of Technology Owerri, Imo State, Nigeria

Imo State Ministry of Health, Imo State, Nigeria

[4]Igwe, Victory Somtochukwu

Department of Food Science and Technology, Federal University of Technology Owerri, Imo State, Nigeria

Abstract

Purpose: The review focused on the management of industrial and communal wastes. Industrial and communal waste management practices are not uniform among countries; urban and rural areas, residential, and industrial sectors, all take different approaches.

Methodology: Industrial wastes can be classified on basis of their characteristics; Waste in dissolved and pollutant is in liquid form, e.g. dairy industry; Waste in solid form, but a number of pollutants within are in the liquid or fluid form, e.g. washing of minerals or crockery industry or coal.

Results: Industrial waste is produced as a result of industrial activities, including materials rendered useless during manufacturing process such as that of food and chemical industries, mills, factories, and mining operations. Dirt and gravel, concrete and masonry, solvents, chemicals, scrap lumber, scrap metal, oil, etc. are types of industrial waste. Industrial or community waste may be liquid, solid, or gaseous. It may be absolutely hazardous, mirror entry, or non-hazardous waste. Hazardous waste can be toxic, ignitable, corrosive, radioactive, or reactive. Industrial waste may pollute the soil, the air, or nearby water bodies, ending up in the sea.

Unique Contribution to Theory, Practice and Policy: Waste management is important component in a business' ability to maintain the ISO14001 accreditation. The ISO14001 standard encourages companies to ensure green environment and improve their environmental efficiencies every year by eliminating waste through the resource recovery practices. The principles of waste management puts some factors into consideration such as waste hierarchy, life-cycle of a product, resource efficiency, and polluter-pays principle. Common waste disposal and management methods include incineration, landfill, recycling, re-use, pyrolysis, resource recovery, composting, among others. An important method of waste management in industries and communities is the prevention of waste materials being created, better known as waste reduction. The waste management industry has adopted new technologies such as Radio Frequency Identification (RFID) tags, GPS, etc., which enable the collection of better quality data without the using estimation or manual data entry.

Keywords: *Waste Management, Industrial Waste Management, Community Waste Management, Principles of Waste Management.*

INTRODUCTION

As more and more industries and businesses are set up, coupled with the increasing rates of urbanization and world population, waste generation from industries and communities in developed and developing countries have continued to increase. Consequently, proper waste management at all levels of the society is required. Waste management are the actions and activities required to manage or treat waste from its origin to its final disposal (United Nations Statistics Division - Environment Statistics, 2017), including its prevention strategies. This includes the collection, transport, prevention, treatment, and disposal of waste, together with the monitoring and regulation of waste management processes. Waste can be liquid, solid, or gas and each type of waste has different methods of management and disposal. Waste management deals with every types of waste, including industrial, residential, and biological. In some cases, waste may pose threat to human health (IFC, 2014). Waste is often produced as a result of human activity, for example, the processing and extraction of raw materials (United Nations Statistics Division - Environment Statistics, 2011). Waste management is intended to reduce the adverse effects of wastes on human health, the environment or aesthetics, and to also improve hygiene. The practices of waste management are not uniform among countries both in developed and developing countries; regions (rural and urban areas), and residential and industrial sectors may all take different approaches (Davidson, 2011). A large part of waste management practices deal with the municipal solid waste (MSW) and wastewater which constitute the bulk of the waste created by industrial, household, and commercial activities; although gaseous waste is also heavily generated, especially by industries.

Industrial wastes are produced as a result of industrial activities, which includes any materials rendered useless during manufacturing process such as that of food and chemical industries, mills, mining operations, and factories. Types of industrial waste are dirt and gravel, scrap metal, scrap lumber, oil, solvents, masonry and concrete, plastics, chemicals, even vegetable matters from restaurants, which may be released to the environment; and can cause harm (Awuchi and Awuchi, 2019a; Awuchi and Awuchi, 2019b). Industrial wastes may be liquid, solid, or gaseous. It can be hazardous, mirror entry, or non-hazardous wastes. As hazardous waste, it may be toxic, corrosive, radioactive, ignitable, or reactive. Waste classified as mirror entry may be toxic depending on some factors. Industrial waste may pollute the soil, the air, or nearby water sources, ending up in the sea (Maczulak, 2010; Awuchi and Igwe, 2017). Industrial waste is usually mixed into the municipal waste, making accurate assessments challenging. An estimate for the United States is as very high as 7.6 billion tons industrial waste produced per year (Recover Inc., 2017). Most countries have enacted different legislations to deal with industrial waste problems, but compliance regimes and strictness vary. Enforcement is often a challenge.

Waste management is an important component in a business' or an industrial ability to maintain ISO14001 accreditation. The ISO14001 standard encourages companies to improve their waste management and environmental efficiencies every year by eliminating waste through the practices of resource recovery. One way this is done is by the adoption of resource recovery practices like the recycling of materials such as food scraps, paper and cardboard, glass, metals, and plastic bottles. Recycled materials can be sold to the construction industries. Many inorganic waste streams may be used to produce construction materials. Concrete and bricks may be recycled as artificial gravel. The topic was among the agenda of the Int’l WASCON conference held in June 2015 in Spain and on the int’l Conference on Green Urbanism, in Italy 12 to 14 October 2016.

INDUSTRIAL AND COMMUNAL WASTES

Principles of Waste Management

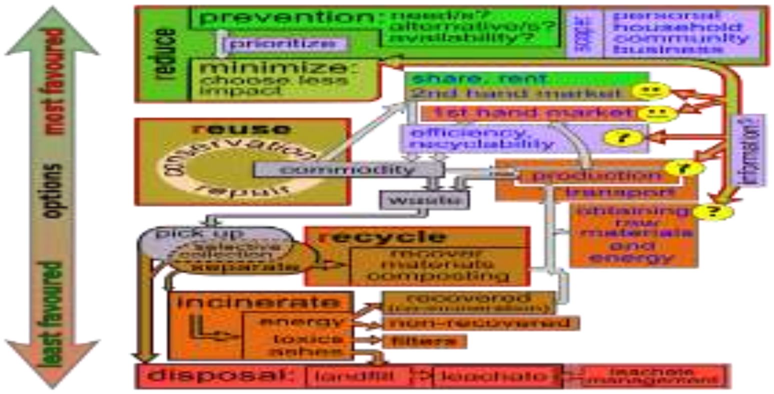


Figure 1: Diagram of the waste hierarchy

Waste Hierarchy

The waste hierarchy explains the 3 Rs, reduce, recycle, and reuse, which classifies the waste management strategies in line with their desirability in terms of waste minimization. The waste hierarchy is the basis of most waste minimization strategies. The aim of waste hierarchy is to extract maximum practical benefits from the products and to generate minimum amount of end waste (Albert, 2011). The waste hierarchy is represented as pyramid because the rudimentary premise is that policies have to promote measures to prevent waste generation. The next step or the preferred action is to seek out for alternative uses for the waste already generated (i.e., reuse). The next is recycling which includes composting. Following this step is material recovery and waste-to-energy. The final action is disposal, through incineration or in landfills without energy recovery. This last step is final resort for waste is not prevented, diverted or recovered (United Nations Environmental Programme, 2013). Even though complete and total prevention of waste is almost impossible, aiming at prevent waste generation is a major efficient way of waste management; at least it reduces waste generation. The waste hierarchy represents progression of a material or product through sequential stages of the waste management pyramid. The hierarchy represents latter parts of life-cycle of a product.

Life-Cycle of a Product

The life-cycle starts with design, and proceeds via manufacture, distribution, and primary use, then follows through waste hierarchy's stages of reduce, recycle, and reuse (the 3 Rs). Each stage in the life-cycle of a product provides opportunities for policy intervention, to redesign to minimalize waste potential, to rethink need for the product, to extend its use (United Nations Environmental Programme, 2013). Product life-cycle analysis is a means to optimize the utilization of the limited resources of the world by avoiding the needless waste generation.

Polluter-Pays Principle

Polluter-pays principle mandates the polluting party to pay for the impact on environment. As regards waste management, this in general refers to the requirement for waste generators to pay for appropriate disposal of unrecoverable material.

Resource Efficiency

Resource efficiency reflects the basic understanding that world economic growth and development cannot be sustained at the current production and consumption patterns. Universally, humans extract more resources to produce goods and services than the planet can replenish (United Nations Environmental Programme, 2013). Resource efficiency is the reduction of environmental impact from production and consumption of these goods, from the final raw material extraction to the last use and then disposal.

Wastes Management in Modern Era

Following the onset of industrialization and the sustained urban growth of the large population centers in England, the buildup of waste in cities caused rapid deterioration in the levels of sanitation and the overall quality of urban life. Streets became choked with the filth due to lack of waste clearance regulations and adequate enforcement. Calls for the establishment of municipal authority with powers of waste removal occurred at 1751, when Corbyn Morris proposed that since the preservation of the people health is of great importance, the cleaning of city have to be put under a uniform public management, and every filth be conveyed by Thames to proper distance in the country (Herbert, 2007). However, it was not until mid-19th century, prompted by the increasingly devastating cholera epidemics and the emergence of public health debate that first legislation on the issue came up. Highly influential in this new effort was the report The Sanitary Condition of the Laboring Population in 1842 of a social reformer, Edwin Chadwick, wherein he argued for the importance of the adequate waste removal and the management facilities to improve health and wellbeing of city's population.

In the United Kingdom, the 1846 Nuisance Removal and Disease Prevention Act began what was to be steadily evolving process of provision of regulated management of waste in London. Metropolitan Board of Works (MBW) was the first citywide authority which centralized regulation of sanitation for the rapidly expanding city; the 1875 Public Health Act made it compulsory for all household to deposit their waste every week in moveable receptacles for waste disposal—the first concept for dust-bin. The intense increase in the waste for disposal led to creation of first incineration plants, or, "destructors" (as they were then called). In 1874, Manlove, Alliott & Co. Ltd. built the first incinerator in Nottingham to the design of Alfred Fryer (Herbert, 2007). However, these were greeted with opposition on the account of large amounts of ash they can produced and which wafted over neighboring areas (Gandy, 1994). Similar municipal systems of disposal of waste sprung up at the turn of 20th century in other big cities of Europe and the North America. New York City became the first United States city with public-sector garbage management in 1895.

Early garbage removal trucks were just open bodied dump trucks which are pulled by a team of horses. They were motorized in early part of 20th century and the first trucks with closed body to eliminate odors with dumping lever mechanism were introduced in Britain in the 1920s. These were shortly equipped with hopper mechanisms in which the scooper was loaded at the floor level and hoisted mechanically to deposit waste in the truck. Garwood Load Packer in 1938 was the first truck to incorporate hydraulic compactor.

Waste Transport and Handling Practices

Waste collection methods widely vary among different regions and countries. Domestic waste collection services are regularly provided by the local government authorities, or by the private companies for commercial and industrial waste. Some areas and regions, especially those in less developed nations, do not have any formal waste-collection system. Curbside collection is the most popular method of disposal in most Canada, New Zealand, United States, European countries, and many other parts of developed world where waste is regularly collected at intervals by specialized trucks. This is usually associated with the curb-side waste segregation. In the rural areas waste might need to be taken to transfer station. The waste collected is then transported to appropriate disposal facilities. In some regions, vacuum collection is used where waste is transported from home or commercial premises by the vacuum along some small bore tubes. Systems are under use in Europe and the North America. In a number of jurisdictions unsegregated wastes are collected at curb-side or from the waste transfer stations and sorted into unusable waste and recyclables. Such systems have the capability to sort large volumes of solid waste, salvaging the recyclables, and turning the remnants into soil conditioner and bio-gas. In San Francisco, the local government (LG) established its own Mandatory Recycling and Composting Ordinance (MRCO) for its goal of the zero waste by 2020, necessitating everyone in the city to keep the recyclables and the compostables out of landfill. The 3 streams are collected with curbside Fantastic 3 bin system – black for landfill-bound materials, blue for recyclables, and green for compostables – provided to businesses and residents and serviced by Recology (San Francisco's sole refuse hauler). The City's system of "Pay-As-You-Throw" charges customers by volume of the landfill-bound materials, which provides financial incentive to separate compostables and recyclables from other discards. In addition, the City's Department of Environment's Zero Waste Program led the City to achieve 80 percent diversion, highest diversion rate in the North America. Other businesses such as the Waste Industries use a range of colors to distinguish between recycling cans and trash.

Financial Models for Waste Management

In most developed countries, disposal of domestic waste is funded from a local or national tax which may be related to the income, or property values. Industrial and commercial waste disposal is usually charged for as commercial service, usually as integrated charge which includes the disposal costs. This practice can encourage disposal contractors to go for the cheapest disposal options such as landfill instead of the environmentally best solution such as recycling and reuse. In some areas such as the Taipei, city government charges industries and households for the volume of waste they produce. The waste is collected by city council if and only if it is put in government issued waste bags. In Uganda, the Kampala Capital City Authority (KCCA) has a waste management unit responsible for charging fees for waste collection and disposal. The residents of these areas try as much as possible to reduce waste generation. These policies have successfully reduced the quantity of waste those cities produce and increased the recycling rates. Morocco has also reported benefits from implementing $300 million sanitary landfill system. Although it may appear to be costly investment, the government predicts that it saved them additional $440 million in damages, or the consequences of failing to properly dispose waste (The Economist, 2018).

Common Waste Disposal and Management Methods

Incineration

Incineration is a waste disposal method wherein solid organic wastes are exposed to combustion in order to convert them into residue as well as gaseous products. Incineration is useful for the disposal of both solid residue from the wastewater treatment and the municipal solid waste. It reduces solid waste volumes by 80 to 95%. Incineration and other high temperature wastes treatment systems are at times described as thermal treatment. The incinerators convert wastes into heat, gas, ash, and steam. Incineration is carried out both on small scale by people and on large scale by industries or government. It is used to dispose solid, gaseous, and liquid wastes. It is recognized as practical method of disposing of some hazardous waste materials (e.g., biological and medical wastes). Incineration is controversial method of waste disposal, because of issues such as the emission of gaseous pollutants. Use of incineration is common in nations such as Japan where land is even more scarce, as the facilities in general do not need as much area as landfills. Energy-from-waste (EfW) or waste-to-energy (WtE) are broad terms for the facilities which burn waste in a boiler or furnace to generate heat, electricity, or steam. Combustion in an incinerator is not at all times perfect and there are concerns about pollutants in the gaseous emissions from incinerator stacks. Mostly, concern has focused on some extremely persistent organic compounds such as furans, PAHs, and dioxins, which may be generated and which may have severe environmental consequences.

Landfill

A landfill site is a site in which waste materials are disposed by burial, as usually seen in most parts of the world. Landfill is oldest form of wastes treatment, though the burial of the waste is modern; historically, the refuse was simply thrown in pits or left in piles.

Recycling

Recycling is a practice of resource recovery that refers to collecting and reusing waste materials such as plastic containers and empty beverage containers. Materials from which the items are produced can be reprocessed into new products. The material for recycling can be collected separately from the general waste using some dedicated bins and collection vans, a procedure known as kerbside collection. In most communities, owner of the waste are required to separate the materials to be collected into different bins (e.g. for metals, paper, plastics) prior to its collection; while in other communities, all the recyclable materials are placed in single bin for collection, and their sorting is handled later at central facility. The latter method is referred to as single-stream recycling. The most commonly recycled consumer products include aluminium such as the beverage cans, newspapers, magazines and light paper, steel from aerosol and food cans, old steel furnishings or equipment, copper such as wire, rubber tyres, glass bottles and jars, polyethylene and PET bottles, paperboard cartons, and corrugated fiberboard boxes. PVC, PP, PS, and LDPE are also recyclable. These items are often composed of single type of material, which make them relatively easy to be recycled into new products. Recycling of complex products (such as electronic equipment, computers) is more difficult, because of the additional dismantling and the separation required. The types of materials accepted for recycling vary by city and country. Every city and country has different certain recycling programs in place to handle the numerous types of recyclable materials. However, some variation in acceptance is reflected in resale value of the materials once reprocessed. In July 2017, Chinese government announced import ban of 24 categories of the recyclables and the solid waste, including plastic, mixed paper, and textiles, placing tremendous impact on the developed countries worldwide, which directly or indirectly exported to China (Walker, 2018).

Reuse

Energy Recovery (Waste-to-Energy)

Energy recovery from wastes is the conversion of non-recyclable wastes materials into usable heat, fuel, or electricity through a range of processes, including combustion, pyrolyzation, anaerobic digestion, gasification, and landfill gas recovery (USEPA, 2014). The process is commonly known as waste-to-energy. The energy recovery from wastes is part of non-hazardous waste management hierarchy. Using the energy recovery to convert the non-recyclable waste materials into heat and electricity, generates renewable energy source and can lessen carbon emissions by offsetting need for energy from the fossil sources and also reduce methane generation from landfills (USEPA, 2014). Globally, waste-to-energy accounts for 16 percent of waste management (Czajczyńska, 2017). The energy content of products of waste can be directly harnessed by using them as direct combustion fuel, or indirectly harnessed by processing them into another fuel type. Thermal treatments range from using waste as fuel source for heating or cooking and the use of the gas fuel as fuel for boilers to generate electricity and steam in a turbine. Gasification and pyrolysis are two related forms of thermal treatments in which waste materials are heated to very high temperatures with limited availability of oxygen. The process usually occurs in sealed vessel under high pressure. The pyrolysis of solid wastes converts the materials into solid, gas, and liquid products. The gas and liquid can be burnt to generate energy or under chemical refinery to make other chemical products. The solid residue (known as char) can be further refined to yield products such as activated carbon. The gasification and the advanced Plasma arc gasification are commonly used to directly convert organic materials into a synthetic gas (called syngas) composed of hydrogen and carbon monoxide (CO). The gas is then burnt to generate steam and electricity. An alternative to pyrolysis is the high temperature and pressure supercritical water decomposition (known as hydrothermal monophasic oxidation).

Biological Reprocessing

The recoverable materials which are organic in nature, such as food scraps, paper products, and plant material, can be recovered through digestion and composting processes to decompose the organic matter. Resulting organic materials are then recycled as mulch or compost for landscaping or agricultural purposes. Additionally, waste gas from the process, e.g. methane, can be captured and be used for generating electricity and heat maximizing efficiencies. The intention of the biological processing in management of waste is to control and accelerate natural process of decomposition of the organic matter.

Pyrolysis

Pyrolysis is the process of thermo-chemical decomposition of organic materials by heat in absence of stoichiometric quantities of oxygen; the decomposition produces numerous hydrocarbon gases. Pyrolysis is usually used to convert various types of industrial and domestic residues into recovered fuels. Different types of waste input (e.g., plant waste, tyres, food waste) placed in the process of pyrolysis potentially yield alternative to fossil fuels. During pyrolysis process, the molecules of the object vibrate at high frequencies to extent that molecules begin to break down.

The rate of pyrolysis increases with the temperature. In industrial applications, temperatures are beyond 430 °C. Slow pyrolysis produces solid charcoal and gases. Pyrolysis hold promise for the conversion of waste biomass into beneficial liquid fuel. Pyrolysis of waste from plastics and wood can potentially produce fuel. Solids left from pyrolysis contain glass, sand, metals, and pyrolysis coke which do not convert to gas. In comparison to the process of incineration, some types of pyrolysis processes release lesser harmful by-products that contain chlorine, alkali metals, and sulphur. However, pyrolysis of certain waste yields gasses that impact the environment such as SO_2 and HCl (Chen *et al.,* 2014).

Resource Recovery

Resource recovery is a systematic diversion of the waste, which was intended for discarding or disposal, for specific next use. It involves the processing of the recyclables to recover or extract materials and resources, or convert them to energy (Government of Montana, 2012). These activities are performed at resource recovery facility (Government of Montana, 2012). Resource recovery is not only environmentally significant, but also cost-effective (Grand Traverse County, 2006). It decreases the amount of wastes for disposal, conserves natural resources, and saves space in landfills (Grand Traverse County, 2006). Resource recovery (as opposite to waste management) uses Life Cycle Analysis (LCA) attempts to provide alternatives to waste management. For mixed Municipal Solid Waste (MSW) many broad studies have shown that administration, source separation and collection followed by recycling and reusing of non-organic fraction and energy and fertilizer/compost production of the organic material through anaerobic digestion to be the favored path. As example of how resource recycling is beneficial, several items thrown away have metals which can be recycled to make profit, such as the constituents in circuit boards. Wood chippings in the pallets and other packaging materials could be recycled to beneficial products in horticulture. The recycled chips can cover walkways, paths, or arena surfaces.

Application of consistent and rational waste management practices can yield a range of benefits including:

1. Economic – Improving economic efficiency via the means of resource use, treatment and disposal as well as creating markets for recycles can result in efficient practices in the production and consumption of materials and products resulting in valuable materials being recovered for reusing and the potential for new business and job opportunities.
2. Environmental – Reducing or eliminating the adverse impacts on the environment by reducing, reusing and recycling, as well as minimizing resource extraction can lead to improved air and water quality and help in reduction of greenhouse gas emissions.
3. Inter-generational Equity – Following the effective waste management practices, it can provide subsequent generations more robust economy, fairer and more inclusive society and cleaner environment.
4. Social – By reducing the adverse impacts on health through proper waste management practices, the resulting consequences are much more appealing civic communities. The better social advantages can result in new sources of employment as well as potentially lifting communities out of poverty particularly in some of the developing poorer nations and cities.

Liquid Waste-Management

Sewage sludge is made by waste water treatment processes. Owing to rapid urbanization, there has been increase in municipal wastewater that results in 0.1 to 30.8 kg of sewage per population equivalent each year (kg/p.e/year) (Syed *et al.*, 2017). Common practices for disposal of sewage sludge are composting, incineration, and landfill.

The Avoidance and Reduction Methods

A key method of waste management is prevention of waste material being generated, known as waste reduction. The methods of avoidance are repairing broken items rather than buying new ones, reuse of second-hand products, designing the products to be reusable or refillable (such as cotton rather than plastic shopping bags), removing any food/liquid remains from cans and packaging, encouraging consumers to avoid using disposable products (such as disposable cutlery) (Recycling Guide, 2008), and designing products which use lesser material to achieve same purpose (for instance, light weighting of beverage cans and food packages).

International Waste Movement

While waste transport in a given country falls under the national regulations, the trans-boundary waste movement is often subject to the international treaties. A major concern to several countries has been hazardous wastes. The Basel Convention, ratified by 172 countries, denounces movement of hazardous wastes from the developed to the less developed nations. The Basel Convention provisions have been integrated into the European Union waste shipment regulations. Radioactive wastes, though considered hazardous, do not fall under the jurisdictions of the Basel Convention.

Waste Challenges in the Developing Countries

Areas with developing economies usually experience exhausted waste collection services in addition to inadequately uncontrolled and managed dumpsites. The problems are worsening (Dao-Tuan *et al.*, 2018). Problems with governance complicate the situations. Waste management in these developing countries and cities is an ongoing challenge because of weak institutions, rapid urbanization, and chronic under-resourcing. All of these challenges, together with lack of understanding of different factors which contribute to hierarchy of waste management, affect treatment of waste (Abarca *et al.*, 2013).

Technologies for Waste Management

Traditionally, the waste management industries have been late adopter of the new technologies such as Radio Frequency Identification (RFID) tags, GPS and the integrated software packages that enable better quality data collection without the use of estimated or manual data entry (Claire, 2014).

INDUSTRIAL WASTE MANAGEMENT

Classification and Treatment

Toxic waste, chemical waste, industrial solid waste and municipal solid waste are designations of industrial wastes. Sewage treatment plants can treat some industrial wastes, i.e. those consisting of conventional pollutants such as biochemical oxygen demand (BOD). Industrial wastes containing toxic pollutants or high concentrations of other pollutants (such as ammonia) require specialized treatment systems (U.S. Environmental Protection Agency, 2011). Industrial wastes can be classified on basis of their characteristics; Waste in dissolved and pollutant is in liquid form, e.g. dairy industry; Waste in solid form, but a number of pollutants within are in the liquid or fluid form, e.g. washing of minerals or crockery industry or coal.

Environmental Impact

Factories and power plants are typically located near bodies of water due to the need for large amounts of water as an input to the manufacturing process, or for equipment cooling. Many areas that are becoming industrialized do not yet have the resources or technology to dispose of waste with lesser effects on the environment. Both untreated and partially treated wastewater are commonly fed back into a near lying body of water. Metals, chemicals and sewage released into bodies of water directly affect marine ecosystems and the health of those who depend on the waters as food or drinking water sources. Toxins from the wastewater can kill off marine life or cause varying degrees of illness to those who consume these marine animals, depending on the contaminant. Metals and chemicals released into bodies of water affect the marine ecosystems. Effective manners in properly removing waste. Wastewater containing nitrates and phosphates often causes eutrophication which can kill off existing life in the water. A Thailand study focusing on water pollution origins found that the highest concentrations of water contamination in the U-tapao River had a direct correlation to industrial wastewater (Gyawali *et al.,* 2012).

Air Pollution

Another evident effect of industrial wastes is air pollution resulting from the burning of fossil fuel. This affects the lives of many individuals because it spreads illnesses. Several environmental issues have devastating effects on third world countries as they have insufficient resources to solve this particular problem (Aivalioti, 2014). This also affects the quality of soil as farmers have to deal with this massive problem. Additionally, nitrogen dioxide is one of the common air pollutants found in the air. Air pollutants have devastating effects on the human because it causes various sicknesses, and some such as carbon monoxide may even cause death if large amounts enter the body beyond the level the body can manage; In Nigeria and other parts of the world, there have been a number of reports on sudden death of people and even entire families due to excessive inhalation of electric generator fumes (mainly composed of carbon monoxide). Ammonia also causes lots of respiratory complications that can be contracted from air. The illnesses that occur from the air pollution include irritation to eyes, skin, throat, or nose. There is also chance of getting Bronchitis or Pneumonia both being extremely dangerous. Commonly, individuals have reported to have headaches, dizziness, and nausea from air pollution (Society National Geographic, 2011). The WHO stated that air pollution is the worst risk on human health (Roser and Ritchie, 2017). Air pollution has been around for long time. Indoor air pollution is also risk for human. This type of air pollution is caused by the burning of solid fuels mainly from cooking or heating (Roser and Ritchie, 2017).

Water Pollution

One of the most devastating effects of industrial waste is water pollution. For most industrial processes, heavy amount of water is used which comes in contact with harmful chemicals. These chemicals are usually metals or radioactive material. This heavily effects the environment because most of waste ends up in oceans, lakes, or rivers. As a result, water becomes polluted posing as health hazard to everyone. Farmers rely on this water but if the water is polluted, then crops that are produced can become polluted. These effect the health of society because if industrial companies can't clean up their waste, this begins to affect the life of humans but also animals. Sea creature's health are affected because their lives become endangered by this polluted water. Water pollution can have devastating effects on the human body with the main ones being infections from bacteria, parasites, and chemicals. "Diseases that humans can be exposed from drinking unsafe water range from cholera, typhoid, or Giardia (Denchak, 2018)."

Management

The United States

The 1976 Resource Conservation and Recovery Act (RCRA) provides for federal regulation of solid waste in the United States. The U.S. Environmental Protection Agency (EPA) has issued national regulations regarding the handling, treatment and disposal of wastes. EPA has authorized individual state environmental agencies to implement and enforce the RCRA regulations through approved waste management programs (U.S. Environmental Protection Agency, 2019).

State compliance is monitored by EPA inspections. In the case that waste management guideline standards are not met, action against the site will be taken. Compliance errors may be corrected by enforced cleanup directly by the site responsible for the waste or by a third party hired by that site (U.S. Environmental Protection Agency, 2019). Prior to the enactment of the Clean Water Act (1972) and RCRA, open dumping or releasing wastewater into nearby bodies of water were common waste disposal methods (US EPA, OAR, 2015). The negative externalities on human health and environmental health led to the need for such a regulations. The RCRA framework provides specified subsections defining nonhazardous and hazardous waste materials and how each should be properly managed and disposed of. Guidelines for the disposal of nonhazardous solid waste includes the banning of open dumping. Hazardous waste is monitored in a cradle to grave fashion. The EPA now manages 2.96 million tons of solid, hazardous and industrial waste. Since establishment, the RCRA program has undergone reforms as inefficiencies arise and as waste management evolves (U.S. Environmental Protection Agency, 2019).

The Clean Air Act (United States) of 1963 and Air Quality Act of 1967 was one of the first moves to start legislating air pollution. It also provided a stricter enforcement on interstate air pollution. The clean Air Act of 1970 increased legislation to limit pollution. For example, mobile sources such as cars, trucks, and industrial sources were on watch by the government. This acts goal was to regulate the spread of ozone, nitrogen dioxide, lead, monoxide, and sulfur dioxide. These six pollutants were categorized as the most common ones according to EPA (United States Environmental Protection Agency) (US EPA, OAR, 2015). Clean Air Act Amendments of 1977: Air quality areas that were under the effect of National Ambient Air Quality Standards (the National Ambient Air Quality Standards) had increased attention to prevent PSD (Prevention of Significant Deterioration). Clean Water Act: CWA of 1972 protects certain areas from waste. Industrial companies are not able to dump in these areas because they are protected by CWA. These are set in places to watch the quality of water. All of these acts have helped to manage pollution in the United States but there is much progress left. With pollution being the leading cause of death as pointed out by Richard Fuller (National Institute of Environmental Health Sciences, 2019). With plans that are under progress, it will not be cheap to maintain pollution in the United States.

China

Levels of water pollution have increased causing diarrhea infections in infants. It has costed around $100 billion to sustain the quality of air and water in China, but if China ignores the quality of water pollution it will worsen. The burning of coal is one the leading causes of air pollution in China, forcing people to wear face masks when going in public. Issues from pollution arise from power plants and factories. This was a report from urban residents who are trying to convince the government to help. The government has tried to manage heavy industry. There are multiple different ways of managing industrial waste. At times there needs to be stricter policies for companies who deal with industrial waste. According to an article, waste heat is often produced and thrown into the environment. Waste heat is produced by water evaporation by the industry. Fossil fuel can be reduced when waste heat is used by industries for their advantage (Hao, 2013). Most effort to reduce industrial waste come from lifestyle changes from humans and more enforcement to the environment (Evangelos, 2012).

London

In order to improve air quality in London, there has been of fund of 20 million pounds. This came from the Our Mayor's Air Quality Fund (MAQF) (London City Hall, 2015). London implemented 12 Emission Low Bus Areas (#LetLondonBreathe 2019). This helps reduce toxic fumes that are released from vehicles. London is in the same situation as in the United States when it comes to managing pollution.

Thailand

In Thailand the roles in municipal solid waste (MSW) management and industrial waste management are organized by the Royal Thai Government, which is organized as central (national) government, regional government, and local government. Each government is responsible for different tasks. The central government is responsible for stimulating regulation, policies, and standards. The regional governments are responsible for coordinating the central and local governments. The local governments are responsible for waste management in their governed area. However, the local governments do not dispose of the waste by themselves but instead hire private companies that have been granted the right from the Pollution Control Department (PCD) in Thailand. The main companies are Bangpoo Industrial Waste Management Center, General Environmental Conservation Public Company Limited (GENCO), SGS Thailand, Waste Management Siam LTD (WMS), and Better World Green Public Company Limited (BWG). These companies are responsible for the waste they have received from their customers before releasing it to the environment, burying it.

Conclusion

Industrial and communal waste management practices are not uniform among countries (developed and developing nations); regions (urban and rural areas), and residential and industrial sectors can all take different approaches. However, waste management is intended to reduce adverse effects of waste on human health, the environment or aesthetics. Industrial waste is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process such as that of factories, industries, mills, and mining operations. Types of industrial waste include dirt and gravel, masonry and concrete, scrap metal, oil, solvents, chemicals, scrap lumber, even vegetable matter from restaurants. Industrial or community waste may be solid, liquid or gaseous. It may be absolutely hazardous, mirror entry, or non-hazardous waste. Hazardous waste may be toxic, ignitable, corrosive, reactive, or radioactive. Industrial waste may pollute the air, the soil, or nearby water sources, eventually ending up in the sea. Industrial waste is often mixed into municipal waste, making accurate assessments difficult. The management of waste is a key component in a business' ability to maintain ISO14001 accreditation. The standard encourages companies to improve their environmental efficiencies each year by eliminating waste through resource recovery practices. The principles of waste management puts some factors into consideration such as waste hierarchy, life-cycle of a product, resource efficiency, and polluter-pays principle. Common waste disposal and management methods include incineration, landfill, recycling, re-use, pyrolysis, resource recovery, composting, among others. An important method of waste management is the prevention of waste material being created, also known as waste reduction. Traditionally, the waste management industry has been a late adopter of new technologies such as RFID (Radio Frequency Identification) tags, GPS and integrated software packages which enable better quality data to be collected without the use of estimation or manual data entry.

REFERENCES

Abarca Guerrero, Lilliana; Maas, Ger; Hogland, William (2013). "Solid waste management challenges for cities in developing countries". *Waste Management*. **33**(1): 220–232. doi:10.1016/j.wasman.2012.09.008.

Aivalioti, Maria (2014). "New opportunities in industrial waste management". *Waste Management*. **34** (10): 1737–1738. doi:10.1016/j.wasman.2014.07.006.

Albert, Raleigh (2011). *The Proper Care and Use of a Garbage Disposal. Disposal Mag.*

Awuchi, C. G.; Igwe, S. V. (2017). Industrial Waste Management: Brief Survey & Advice to Cottage, Small and Medium Scale Industries in Uganda. *International Journal of Advanced Academic Research*, 3 (1); 26 – 43. ISSN: 2488-9849.

Awuchi, Chinaza Godswill and Awuchi, Chibueze Gospel (2019a). Physiological Effects of Plastic Wastes on the Endocrine System (Bisphenol A, Phthalates, Bisphenol S, PBDEs, TBBPA). *International Journal of Bioinformatics and Computational Biology*. Vol. 4, No. 2, 2019, pp. 11-29. http://www.aascit.org/journal/archive?journalId=809

Awuchi, Chinaza Godswill and Awuchi, Chibueze Gospel (2019b). Impacts of Plastic Pollution on the Sustainability of Seafood Value Chain and Human Health. *International Journal of Advanced Academic Research*, 5 (11); 46 – 138. ISSN: 2488-9849.

Chen, Dezhen; Yin, Lijie; Wang, Huan; and He, Pinjing (2014). "Pyrolysis technologies for municipal solid waste: A review". *Waste Management*. **34** (12): 2466–2486. doi:10.1016/j.wasman.2014.08.004.

Claire Swedberg (2014). *"Air-Trak Brings Visibility to Waste Management". RFID Journal.*

Czajczyńska, D.; Anguilano, L.; Ghazal, H.; Krzyżyńska, R.; Reynolds, A.J.; Spencer, N.; and Jouhara, H. (2017). "Potential of pyrolysis processes in the waste management sector". *Thermal Science and Engineering Progress.* **3**: 171–97. doi:10.1016/j.tsep.2017.06.003.

Dao-Tuan, Anh; Nguyen-Thi-Ngoc, Anh; Nguyen-Trong, Khanh; Bui-Tuan, Anh; and Dinh-Thi-Hai, Van (2018), *Chen, Yuanfang; Duong, Trung Q. (eds.), "Optimizing Vehicle Routing with Path and Carbon Dioxide Emission for Municipal Solid Waste Collection in Ha Giang, Vietnam", Industrial Networks and Intelligent Systems,* Springer International Publishing, **221**, pp. 212–227, doi:10.1007/978-3-319-74176-5_19, ISBN 9783319741758

Davidson, Gary (2011). *"Waste Management Practices: Literature Review". Dalhousie University - Office of Sustainability.*

Denchak, Melissa (2018). *"Water Pollution: Everything You Need to Know". Our Stories.* New York: Natural Resources Defense Council.

Evangelos, Gidarakos (2012-03-15). "New opportunities in industrial waste management". *Journal of Hazardous Materials.* 207-208: 1–2. doi:10.1016/j.jhazmat.2011.10.083.

Gandy, Matthew (1994). *Recycling and the Politics of Urban Waste. Earthscan. ISBN 9781853831683.*

Government of Montana (2012). *"Resource Recovery"*. Government of Montana. 2012.

Grand Traverse County (2006). *"What is Resource Recovery?"*. Grand Traverse County. 2006.

Gyawali *et al.* (2012). *"Effects of Industrial Waste Disposal on the Surface Water Quality of U-tapao River, Thailand"*. 2012 International Conference on Environment Science and Engineering. **32**: 5.

Hao, Fang (2013). "Industrial waste heat utilization for low temperature district heating". *Energy Policy*. **62**: 236–46. doi:10.1016/j.enpol.2013.06.104.

Herbert, Lewis (2007). *"Centenary History of Waste and Waste Managers in London and South East England". Chartered Institution of Wastes Management.*

IFC (2014). *"Editorial Board/Aims & Scope". Waste Management.* ***34*** *(3): IFC. March 2014. doi:10.1016/S0956-053X(14)00026-9.*

London City Hall (2015). *"Mayor's Air Quality Fund"*. London City Hall. 2015-03-17.

Maczulak A. E. (2010). *Pollution: Treating Environmental Toxins.* New York: Infobase Publishing. p. 120. ISBN 9781438126333.

National Institute of Environmental Health Sciences (2019). *"Pollution is a global but solvable threat to health, say scientists (Environmental Factor, January 2019)"*. National Institute of Environmental Health Sciences.

Recover Inc. (2017). "*Industrial Waste Management: Waste Stream Statistics*". Recover Inc. 2017-02-28.

Recycling Guide (2008). *"Removing food remains to reduce waste"*. Recycling Guide. 14 February 2008.

Roser, Max and Ritchie, Hannah (2017). *"Air Pollution". Our World in Data.*

Society, National Geographic (2011). *"air pollution". National Geographic Society.*

Syed Shatir, A. Syed-Hassan; Wang, Yi; Hu, Song; Su, Sheng; and Xiang, Jun (2017). "Thermochemical processing of sewage sludge to energy and fuel: Fundamentals, challenges and considerations". *Renewable and Sustainable Energy Reviews.* **80**: 888–913. doi:10.1016/j.rser.2017.05.262.

The Economist (2018).*"How the world should cope with its growing piles of rubbish". The Economist.*

U.S. Environmental Protection Agency (2011). *Introduction to the National Pretreatment Program.* Washington, D.C.: U.S. Environmental Protection Agency. 2011. pp. 1–1, 1–2. EPA 833-B-11-001.

U.S. Environmental Protection Agency (2019). *"Resource Conservation and Recovery Act Overview"*. EPA. 2019-02-06.

United Nations Environmental Programme (2013). *Guidelines for National Waste Management Strategies Moving from Challenges to Opportunities*. United Nations Environmental Programme. 2013. ISBN 978-92-807-3333-4.

United Nations Statistics Division - Environment Statistics (2011). *unstats.un.org.*

United Nations Statistics Division - Environment Statistics (2017). *unstats.un.org.*

US EPA, OAR (2015-05-27). "*Clean Air Act Requirements and History"*. US EPA.

US EPA, OAR (2015-05-29). "*Evolution of the Clean Air Act"*. US EPA.

USEPA (2014). *"Energy Recovery from Waste"*. USEPA. 2014.

Walker, T. R. (2018). China's ban on imported plastic waste could be a game changer. *Nature*, 553(7689), 405-405.