SUSTAINABILITY STUDIES: ENVIRONMENTAL AND ENERGY MANAGEMENT

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Sustainability Studies: Environmental and Energy Management

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CONTENTS

PREFACE

The purpose of this book, "Sustainability Studies: Environmental and Energy Management" is to provide a continuous state-of-the-art critical view of the current knowledge of the environment and energy management. Recent Global warming, heat around the earth, pollution, unpredicted atmosphere changes, and contaminants such as physical and biological components severely affect the normal environment. There are no boundaries observed for these environmental stressors and pollution. Recently these two factors have been considered to have a significant role environmental as well as energy management.

This book covered various topics related to the fundamental nature of contaminants, their measurements, characterization and different techniques for their removal.

With this idea, we have chosen authors from different countries with varied backgrounds who could add the issues and solutions which provide the readers an understanding of global issues in a comprehensive better manner. In the beginning, a country or a person who has an interest in environmental and energy management can build a platform. It is imperative that we can build a strong management system globally.

The diversity of authors helps us disclose the advances in environmental and energy management worldwide. Their inputs will let the readers know about the problems and issues faced by academic individuals, industries, and research institutions and the directions for future prospects.

This book presents a complete lookout to provide a source of information on all facets of environmental and energy management for undergraduate and post-graduate students, researchers both industrial and academicians in the field of environmental and energy management.

As the editors of this book, we are sure that the book chapters surely guide the students and researchers with unexplored avenues and future perspectives in environmental and energy management to identify promising solutions that might represent future solutions in these critical areas.

Jeeva Chithambaram authored a chapter titled "Alternative building materials-Road to Sustainability" where they discussed the building materials which are made from industrial waste as conventional building materials for sustaining the environment from degradation.

The chapter titled "preparation of environmental friendly thin films using SILAR method" by mani describes how thin films are prepared by the SILAR method, adopting some simple adsorption and reaction of the ions from the solution as a chemical method.

Shenbagavadivu has written a chapter on "Smart waste management to enrich cleanliness and reduce pollution in environment". They conversed about the importance of solid waste management to safeguard public health by adopting a smart solid waste management system for garbage collection to enhance environmental sustainability which can render support to the economic growth of the Nation.

The chapter titled "A new philosophy of production" is written by Markic. It discusses the growth and development of society on our planet by the consumption of natural resources which lead to increase the production of waste and other substances which are harmful for both human beings as well as the ecosystem. Considering the several factors such as circular economy, industrial ecology, ecological economy, blue economy, biomimicry, cradle to cradle, cleaner production and regenerative design, they discussed the approach to production to ensure that man functions in accordance with natural laws, and that we need to leave nature and the environment in a much better condition than we inherited.

Lakshmana Prabu and Thirumurugan authored a chapter titled "Remediation approaches for the degradation of textile dye effluents as sustaining environment". They have deliberated on the impact of textile dye effluents and different remediation approaches in order to maintain the sustainability of this environment in near future.

The chapter titled "A comparative adsorption study of acid violet 7 and brilliant green dyes in aqueous media using rice husk ash (RHA) and coal fly ash (CFA) mixture" is written by Irvan. They demonstrated the adsorption of dyes such as acid violet 7 (AV7) and brilliant green (BG) in the mixture of rice husk ash (RHA) and coal fly ash (CFA) as adsorbents and highlighted that RHA-CFA can act as a very good adsorbent to remove AV7 and BG from aqueous medium.

Ashok Kumar discusses the "Pollution Prevention Assessments: Approaches and Case Histories" in Ohio, USA. This chapter focuses on pollution prevention by applying the concept of energy efficiency, energy savings, greenhouse gas emission (GHG) reductions, waste reduction, and stormwater management.

The chapter "Threats to sustainability of land resources due to aridity and climate change in the northeast agro-climatic zone of Tamil Nadu, South India" by Dhanya is based on the Aridity Index.

It was a great experience to write and edit this book. We acknowledge the full support of all the authors and specially thank particularly the support extended by Bentham Science and their team had been extremely supportive in the completion of this book.

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CHAPTER 1

A New Philosophy of Production

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Abstract: The growth and development of society on our planet has caused a great consumption of natural resources and, on the other hand, the production of waste and other substances harmful both to human health and to the ecosystem itself. With this way of life, man has moved away from nature. Consequently, a system that functions contrary to natural laws has been established. With the new way of production, it is necessary to return to natural processes and sustainable technologies, clean technologies, and the use of renewable energy sources. The projection of sustainability in the future must be based on resource use restriction, material reuse and other principles of economic and environmental sustainability. This chapter will discuss the new approach to production and the product itself through the consideration of several different possibilities such as circular economy, industrial ecology, ecological economy, blue economy, biomimicry, cradle to cradle, cleaner production and regenerative design. The above-mentioned possibilities in production, design and the product itself aim to ensure that man functions in accordance with natural laws, and that we need to leave nature and the environment in a much better condition than we inherited.

Keywords: Biomimicry, Blue Economy, Circular Economy, Cleaner Production, Cradle to Cradle, Industrial Ecology, Regenerative Design.

INTRODUCTION

A new philosophy of production in the 21st century, or sustainable production, is to create goods and services using processes and technologies that will not create pollution, save energy as well as reduce the pressure on resource depletion. In addition, this production must be economically sustainable, safe, and secure for employees, the local community, and consumers. Sustainable production should reduce the consumption of raw materials and energy per unit of product, as well as improve the quality of the environment and social well-being [1].

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Since the 1970s, the management and control of pollutant emissions have been based on the exhaust pipes or chimneys, the so-called "end-of-pipe" technology. In any case, this approach to environmental pollution control has yielded results in many aspects, but the regulations have not been aimed at preventing pollution or impacts in the future. New technologies deal with the cause of the problem, as opposed to "end-of-pipe" technologies that deal with symptoms. It often happened that pollution was transferred from one environmental medium to another (water, air, land) or transferred to other geographical areas and other countries. This has resulted in an increasing search to solve problems by changing the production process, rather than treating pollution at the end of the production process.

If we look at the specific strategies of companies, we can determine the focus on disposal and recycling technologies, which are mainly "end-of-pipe" technologies. These technologies are supplemented to the original production process without introducing major changes in the technical system, where the existing technology is supplemented with new components in order to avoid or reduce the negative impact on the environment. So, we have a supplementation of the existing technological process with a filtration and purification plant, disposal method, and recycling technology [2]. "End-of-pipe" technologies essentially continue production without changing the existing technical system, *i.e.*, stabilizing the existing technological system with correcting possible negative impacts on the environment [3].

CIRCULAR ECONOMY

Beginning with the industrial revolution, the global economy is characterized by a significant model, the so-called linear model of production and consumption. The linear model of economics operates on the principle of "take, make, use and discard", according to which all products that man no longer needs end up as waste [4]. It is a well-established practice that products are created at low prices, used and discarded. This approach in a linear economy results in unsustainable extraction of natural resources and the accumulation of pollution [5]. If resource consumption continues at this pace, by 2050, it would take the equivalent of over two planets to support this development and it would not be possible to achieve the better standard of living it aspires to. This approach, from the aspect of economics, has initiated deliberation about the unsustainability of such a model, that is, the unsustainability of modern civilization. On the other hand, the resources on Earth are not infinite and are becoming increasingly endangered. The growth and development of technology have led to a reduction in production and sales prices, to the growth of the living standard of the population, but also to an uncontrolled imbalance between the economic and ecological systems [6]. At the end of the 1970s, we moved toward the direction of extending the life of products as well as reducing the amount of waste through the introduction of a new model of the so-called circular economy.

Geissdoerfer *et al*. [7] define “the Circular economy as a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops”. The circular economy, with its 3R principles of reducing, reusing and recycling material clearly illustrates the strong linkages between the environment and economics [8]. The circular economy strives to operate on a “product-waste-product” principle, *i.e*. to ensure sustainable resource management, extend product life, reduce waste and use renewable energy sources. With this new approach, waste is almost non-existent, *i.e*. it has been reduced to a minimum.

As shown in Fig. (**1**), at each stage in the circular economy, the aim is to reduce costs and dependence on natural resources, as well as to reduce the amount of waste. This model replaces the “end of life” concept with restoration, the use of renewable energy sources, and the elimination of the use of toxic chemicals. The value of products and materials is maintained for as long as possible and waste is minimized. The product is produced, used, and after reaching its end *i.e*. its service life, the resources it contains are reused, that is the process returns to the beginning. For example, factory waste becomes valuable in another process, products can be repaired, reused or upgraded instead of being thrown away.

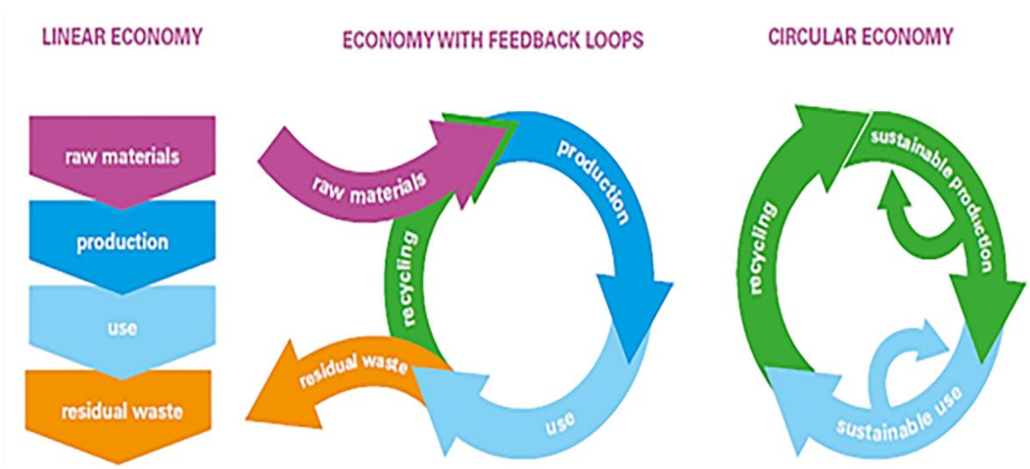

Fig. (1). Linear and circular economy [9].

The circular economy aims to increase the quality of life of citizens, with more efficient use of resources, increased competitiveness, creation of new jobs through

CHAPTER 2

Alternative Building Materials – Road to Sustainability

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Abstract: The fundamental and most essential components in building construction are materials. Good design along with the properties of materials (chemical, physical and mechanical) are accountable for a building's material strength. The concept of sustainability in building materials revolves around the development and use of eco-friendly materials that have the same or enhanced properties as compared to that of conventional building materials. However, in the recent past, the use of conventional building materials in building construction has resulted in environmental degradation. Sustainability can be achieved by using industrial waste materials (by-products) and/or recycling and reusing the materials in building construction. Cost (manufacturing and transportation) has been a predominant factor considered while comparing related materials for the same purpose. This chapter discusses the need for alternative sustainable building materials with regard to energy and environmental impact caused by traditional or conventional building materials. Also, this chapter discusses sustainable initiatives carried out by researchers to discover low technology construction techniques. Further, this chapter discusses how alternative building materials can lessen the impact of environmental degradation, resulting in a healthier, cost-effective, and sustainably safe living environment.

Keywords: Alternate building materials, Building Materials, Eco-friendly materials, Sustainability.

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INTRODUCTION

Housing is considered to be one of the elementary needs of human life and it is a key competent to the sustainable development of a nation. All materials used for construction purposes in buildings are known as building materials. They play a major role in technology as well as in a nation's economy. These materials form the basis of materials found in construction engineering. These materials are used in foundations, floors, walls, beams, roofs, *etc*.

Building materials differ from place to place and the choice of materials depends on certain factors with respect to availability, climate, economy, *etc.* Different materials have been developed around the world with regard to their properties and environmental impact. Also, the fast-growing advancements in construction practices, tools and machinery or technologies may lead to a need for new building materials that could satisfy the increasing demand.

Almost thirty years ago, Sustainable Development gained attention after the 1992 Earth Summit [1] and Brundtland's report entitled "our common Future" [2]. The concept of sustainable development has been defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This concept of sustainability includes enhancing the value of life, thereby letting people live in an atmosphere that is healthy, with better-quality social, economic and ecological conditions. In order to maintain sustainability in recent years, there has been a list of global issues that need to be taken care of. Some of the global issues are listed as follows:

- Weather change,
- Air pollution,
- Lessening of natural resources,
- Biodiversity,
- Waste generation,
- Reduction as well as pollution of water resources, and
- A decline in urban environment.

The emission of carbon dioxide (CO_2) along with other greenhouse gases (GHG) is a result of climate change and global warming. They pose an enormous risk to human wellbeing. In order to contain the hazard, the world needs to reduce the emissions by the use of alternate materials. A huge amount of CO_2 is released into the air throughout the whole life of a building. This comprises the manufacture of building materials, construction of a building, excavation, renovation, possible rehabilitation, and also its ultimate demolition [3].

As per United Nations projections, with regard to the unprecedented rates in a growing population, the total world's population is estimated to reach 9.8 billion in 2050 [4].

CLASSIFICATION OF BUILDING MATERIALS

Generally, building materials are classified based on their chemical composition into three types, namely, inorganic, organic, and composite materials, as given in Fig. (**1**).

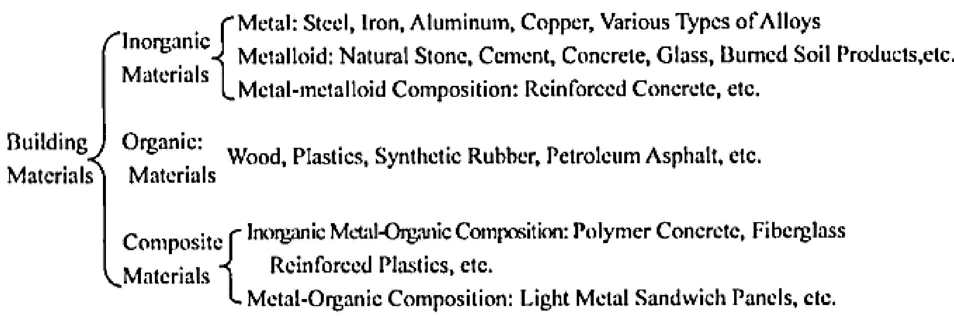

Fig. (1). Classification of building materials.

Also, they are classified as structural materials and functional materials based on the functions of materials. Structural materials are used in beams, columns and plates. Functional materials are used for special purposes like waterproofing, heat-insulating function and ornamental purposes.

Furthermore, building materials can be used based on their physical, chemical and mechanical properties. Some of the physical properties that need to be assessed are density, bulk density, specific weight, specific gravity, porosity, void ratio, water absorption, water permeability, fire resistance, heat conductivity, chemical resistance, *etc.* Some of the mechanical properties of building materials that need to be assessed are strength, hardness, elasticity, plasticity, *etc.*

Some of the traditional building materials used in construction are classified based on their structural, insulation and complementary materials. The most common structural materials are wood, stone, rammed earth, straw bales, clay bricks, cement, *etc.* Some of the most common insulating materials are sheep wool, fibres, *etc.* Plasters, paints and flooring materials are some of the most commonly used complementary materials.

Stone is one of the oldest construction materials, which is considered to be highly durable along with a low maintenance cost. After stone, wood is considered to be

CHAPTER 3

Smart Waste Management to Enrich Cleanliness and Reduce Pollution in the Environment

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Abstract: The forecast of waste generation is an essential step for adequate waste management planning since it involves various factors that can affect waste trends. Due to over-population in urban areas, the rate of garbage production has been increasing rapidly. To simplify the process, a proposed solution for a smart solid waste management system has been implemented. The proposed smart bin has a faster and more intelligent separation process of the waste material.

Keywords: Ardunio Uno Board, Compressor, Infra-red sensor, LED, Solar battery backup, Solar panel, Temperature sensor, Ultra sonic sensor.

INTRODUCTION

Various critical factors, including its prime location, clean ambience, abundant water, polite people, religious harmony, good rail, road, and air connectivity, have all contributed to a modest increase in the number of tourists visiting the city. In the coming decades, solid waste management (SWM) will be an important parameter in accurately judging a civic body's accomplishment. Solid waste management is categorized into various forms, namely bio-degradable waste, non-bio-degradable waste, and hazardous waste [1]. In recent days, COVID-19, also known as the coronavirus, has been said to lead to the life thread of human life since the infectious diseases are spread to humans *via* sneezing, coughing, touching, saliva, *etc*. In the hospital, wastes such as blood bags, syringes, cotton, dresses, masks, and so on are not properly collected or dumped.

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Due to this improper collection of waste materials, the virus can be spread to the environment, and the number of affected patients will increase rapidly. All three types of waste products are collected through the garbage bin at a common place in an area/street [2]. The accumulation or overflow of garbage from the bin leads to the environment getting polluted due to the lack of collection of garbage from the streets. This typically happens because the local collector does not know about the garbage naturally produced or garbage piled in the local streets. In the current process, a responsible person has to wander through the different spots and carefully check the places for waste collection. This is a somewhat complex and time-consuming process [3]. In the present day, a waste management system is not as efficient as it should have been, taking into consideration the advancements in technology that have naturally arisen in recent years. There is no surety about the management/clearing of waste at all the places. There is a pressing need to maintain the city's hygiene and protect the environment from degradation to avoid unhealthy environments. To prevent the accumulation or overflow of garbage waste in the bin, a new approach to smart solid waste management (SSWM) systems is proposed [1]. It is a necessary step forward for making the waste collection process automatic and efficient in nature [4, 5].

CURRENT STATUS OF THE GARBAGE COLLECTION

Solid Waste Management in Italy

About 58.5 million people live in Italy, a European country. It has three macro-geographical areas, namely: North and South. These three regions consist of nearly 20 regions. In 2019, Italy generates about 51.1 million metric tonnes of municipal solid waste (MSW). In total MSW production, 32.7% is the source-separated collection of recyclables and compostable [6]. The North and South each reached a value of 55.5%, 28.3%, and 18.1%, respectively. MSW combusted at waste-to-energy (WTE) ranged from about 1.6 million tonnes to 3.5 million tons. The North sends to WTE facilities the largest quantity of MSW and RDF (refuse derived fuel) [2]. About 9 million tonnes of MSW would be managed by the mechanical-biological treatment in 2019, increasing the production of compost and bio-stabilized, dry fraction, or RDF, by 40% and 80%, respectively. The number of landfills in Italy decreased from 657 to 401 between 2011 and 2019. In the south of Italy, most of the landfills are present in areas in which the landfills are not uniform [7]. From 2000 to 2004, the use of landfills decreased from 72.4% to 51.9%, but Italy remains the principal method of disposal. WTE increased from 8.5% to 9.7% [3]. Between 2011 and 2019, the use of mechanical-biological treatment and composting remained constant at about 28%.

Solid Waste Management in Switzerland

In Switzerland, municipal solid waste (MSW) has been increasing from year to year. It reached 720 kg per person in 2007. Swiss recycling rates are among the highest in the world. Their recycling principle is applied very swiftly everywhere. Electricity and heat are generated by incinerating wastes in the incinerating process, which accounts for about 2% of the country's final energy requirements [8]. The level of environmental pressure has been reduced by the Swiss Confederation's waste management policy. The introduction of high waste management standards leads to the creation of a highly effective infrastructure. Waste producers are responsible for the cost of disposal, which is made by the financing system. Highly effective waste policies are even insufficient in reducing the country's overall consumption of resources [4]. Hazardous waste accounts for approximately 6% of total waste. For special reprocessing, 1.2 million tonnes of hazardous waste are consigned, or wastes are exported in line with the control of Tran's boundary movements of hazardous wastes and their disposal [9]. Over 1 billion francs will be spent on remediating disused hazardous waste landfill sites.

Indian Scenario and Technological Gap

Garbage is waste generally thrown out of our homes, offices, shops and restaurants. In our country, almost half of it consists of rotting vegetables and food matter [3]. Besides, it also contains paper, plastic, glass, rubber, leather, coal, metal, rags, toxic materials (such as batteries, pesticides, paints, and chemicals), building materials, and soil. According to the Central Pollution Control Board (CPCB), the average Indian generates about 490 tons of waste per day [10]. Although the per capita waste is low compared to western countries, the volume is huge. The generation of solid waste in Indian cities has been estimated to grow by 1.3 percent annually. The expected generation of waste in 2025 will therefore be around 700 tons per capita per day [5]. Considering that the urban population of India is expected to grow to 45 percent from the prevailing 28 percent, the magnitude of the problem is likely to grow even larger unless immediate steps are taken [11]. While the quantity of solid waste generated by society is increasing, the composition of waste is becoming more and more diversified, with the increasing use of packaging materials made of both paper and plastic. Thirty years ago, the composition of solid waste generated by the Indian farmer was characterized by one-fifth non-biodegradable waste and four-fifths biodegradable waste [6]. This ratio is about to reverse; currently, only 40% of all solid waste is biodegradable, while 60% is non-biodegradable.

CHAPTER 4

Remediation Approaches for the Degradation of Textile Dye Effluents as Sustaining Environment

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Abstract: Water has been considered one of the most valuable substances on earth for almost entire living organisms, from the largest mammal to the smallest microorganism. In addition, water is essential for the healthy life of human beings, animals, plants, *etc.* due to rapid, swift, and advanced industrialization, polluted water is discharged from different industries on many occasions. Among the different industrial pollutants, textile dyes and their effluents are the most predominant pollutants. Nearly 100,000 synthetic dyes are produced, and about one million tons of dyes are utilized for various dying purposes. About 10% of the dyes are unconfined into natural resources and the environment as waste, which spoils the aesthetic nature of the environment. These colored dyes are carcinogenic or mutagenic. These colored dyes are very fine particles in nature, and their concentrations of about 1 ppm are visible. These discharged color dyes cause grave intimidations with numerous problems; hence, these discharged color dyes as industrial waste have been considered as a major problem in the wastewater treatment process. In this chapter, various remediation techniques for the degradation of textile dyes effluents are discussed to maintain the sustainability of the environment.

Keywords: Biological methods, Effluent treatment techniques, Electrochemical Methods, Physical-Chemical methods, Phytoremediation Green Nanotechnology, Textile dye, Azo dye.

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INTRODUCTION

The foremost important substance on the earth is water, which has been fundamentally required for the survival of every living organism from the biggest mammal to the smallest organisms. In simple words, without water, there will be no life on earth. Animals, plants, and organisms utilize water for their healthy growth as well as for their production by aerobic respiration; whereas without water there is no aerobic respiration. Commonly the living organism creates ATP as a source of energy for their life through the aerobic respiration process. Most of the organisms are made up of a minimum of 50% however few of the organisms are made with 95% of water. Water must be clean for humans to have a healthy life also it should be free from chemicals and microorganisms (https://sciencing.com/about-6384365-water-important-life-earth-.html) [1].

Diverse water resources are:

1. Springs

2. River water

3. Surface water

4. Rock holes and rock catchment areas

5. Excavated dams

6. Rainwater

7. Bores and wells

8. Artesian bores (http://www.health.gov.au/internet/publications/publishing.nsf/Content/ohp-enhealth-manual-atsi-cnt-l~ohp-enhealth-manual-atsi-cnt-l-ch6~ohp-enhealth-manual-atsi-cnt-l-ch6.1) [2].

Derivation of Synthetic Dye

From ancient times, different colorants have been utilized by human beings from their routine life practices like painting, cloth coloring, dyeing, *etc.*, Walls were colored by using dyes during 15000-9000 BC itself (Altamira caves in Spain). Until the 17th-century insects, plants and mushrooms were used as a natural dye source especially in textile dying (Shah 2018) [3]. In general, these natural dyes are made with aromatic compounds; while these dyes require several steps in the dyeing process, which is a main drawback of the same.

In 1856, W.H. Perkin has tried to synthesis quinine, unfortunately, the outcome of that particular research produced a blue color substance that had respectable dyeing character. Subsequently blue color has turned into violet aniline and purple tyrant color (Aksu and Karabayir 2008) [4].

Rapid industrial advancement and development made a new demand in the dyeing technique which created a new gateway in the dyeing industry to produce different synthetic dyes. To encounter the present need, about ten thousand types of dyes are manufactured; also almost 1,000,000 tons of dyes are produced exclusively for textile industry purposes (Robinson *et al.,* 2001) [5].

Classification of Dyes

Dyes are molecules having conjugated double bonds in delocalized electronic systems; chromophore and auxochrome are the major groups in the dyes. In general, a chromophore is an electron-withdrawing group of atoms that have a major role in the dye color. Some vital chromophore groups in the dyes are -N = N-, -C = N-, -C = O, -C = C-, -NO and $–NO_2$. But auxochrome is an electron donor substituent group and responsible for the electronic system energy modification, which increases the chromophore color. Some vital auxochrome groups in the dyes are - NH_2, $-NR_2$, NHR, - SO_3H, -OH, $-OCH_3$, and –COOH (Aksu and Tezer 2005; Alhassani *et al.,* 2007) [6, 7].

The chemical molecular structure of the dyes has an important role in the dye's color against the decline of color when exposed to light and water. Textile industry dyes are categorized into anthraquinone, basic, azo, diazo, cationic, anionic, and nonionic based on their chemical structure. However the dyes consist of anthraquinoid, azo aromatic, and indigoid structure which allow strong π-π transitions through high extinction co-efficient in UV visible area; but the azo aromatic dye is the more widespread between these three dyes (Palanivelan *et al.,* 2013) [8].

Azo dyes have one or more nitrogen–nitrogen double bonds (–N==N–); further classified into mono-azo dyes, diazo dyes, tri-azo dyes, and poly-azo dyes (more than three azo groups) based on the number of azo groups. The major merits of these azo dyes are ease of synthesis and cost-effectiveness; demerits are such as it can't be simply besmirched by aerobic and anaerobic bacteria (Shivangi 2012) [9].

CHAPTER 5

Composting of Fruit Wastes - An Efficient and Alternative Option for Solid Waste Management

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Abstract: Municipal solid waste generation is exponentially increasing every year. Managing these solid wastes is highly complicated due to the generation of a plethora of waste. Since collecting and disposing of wastes in dumping sites cause severe environmental impacts, an alternative option is the need of the hour. Thus the technique used must be efficient and less in cost for agricultural applications. Composting is one such process where the decomposition and recycling of organic material into a humus-rich soil take place naturally known as compost. Fruit waste is rich in moisture content, and thus possesses a unique property as a raw compost agent. The present study focuses on composting of fruit wastes for reducing the amount of solid waste being collected and dumped. If composting of fruit waste is carried out in backyards, then the amount of solid waste entering the dumping sites can be reduced substantially.

Keywords: Composting, Humus-rich soil, Municipal solid waste.

INTRODUCTION

Solid waste disposal is one of the primary environmental problems faced by the country presently since it destroys both the environment and the ecological cycle [1]. The contribution of solid wastes is estimated to be about 40% of organic wastes which can be reused and converted into environmentally compatible products [2]. When these organic wastes are left unattended, two adverse effects can occur. Firstly, the unbearable smell it causes due to natural decomposition and secondly, it gives rise to severe health problems by feeding insects and pests. Hence the recycling or reuse of organic waste is necessary.

Food waste is one of the major contributors to solid waste, and when it is not composted, it goes directly to a landfill. This organic matter may react with other

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materials in thelandfill and create toxic leachate [3]. Food waste has the capacity to stop the earth's natural cycle of decomposition when placed in an airtight landfill. Composting can be done by separating, segregating and decomposing by biological means [3, 4]. Composting is considered to be the most economical and sustainable option for organic waste management [5] since it provides a way in which solid wastes, water quality, and agricultural concerns can be joined. This compost not only increases the water and nutrient holding capacity, thereby improving the soil quality but also reduces waste going to landfills, improves plant productivity, and reduces water runoff and soil erosion [6].

Food waste is rich in moisture content and thus possesses a unique property as a raw compost agent. Hence it is important to mix fresh food waste with a bulking agent that will absorb excess moisture as well as add structure to the mixture [7]. Many factors play an active role in the composting process. Some of the factors are C/N ratio, moisture content, temperature, oxygen content, particle size, porosity and bulk density [8]. The loss of nutrients and the time required for composting can be minimized by optimizing these operating parameters [9].

At present, an environmentally friendly technology is most important for utilizing organic waste. Composting is one such important and efficient method of solid waste management [10]. The compost not only reduces the amount of waste but it can also be used for improving soil fertility; hence reducing the amount of fertilizer to be used in the land [2]. The present study aimed to compost fruit waste to reduce the amount of solid waste being collected and dumped.

COMPOSTING METHODS

There are various methods of composting. Some of them are given below:

Bin Composting is typically used for small amounts of food waste. They require little labor, use wire mesh or wooden frames for better air circulation, and are inexpensive. Three chamber bins that can handle significant quantities of materials are used for faster compost production utilizing varying stages of decomposition. This bin composting process also allows staged composting, with one section used for storing compostable materials, one section for active composting, and one section for finished compost [1].

Vermi Composting is the most commonly used composting process that uses worms to consume food waste. This type is usually done in containers or bins as shown in Fig. (**1**). As an environmental education tool, many educational institutions use this method for high quality compost. One of the main disadvantages is that the investment in worm stocking may be high depending on the size of the operation. The investment in worm stocking may be high depending on the size of the operation. Also, if too much waste is added, anaerobic conditions may occur [2].

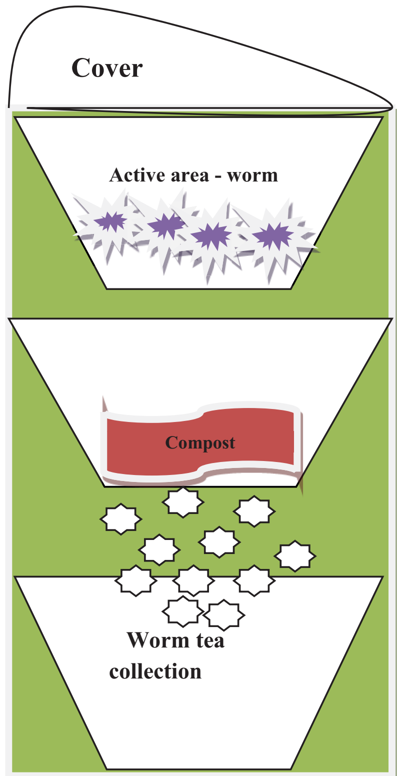

Fig. (1). Vermicomposting.

Aerated Static Piles Method- In this method, there are three layers, namely, plenum, active and biofiltration layer. The air is introduced to the stacked pile using perforated pipes and blowers as shown in Fig. (**2**). It is then slowed and diffused in the plenum layer and the active layer promotes aerobic composting. The final biofilteration layer traps heat and prevents the escape of odour. Since this method is weather sensitive, it requires no labor and due to imperfect mixing, it can have unreliable pathogen reduction [2].

Windrows Method is used for larger volumes and requires huge space. This method produces a uniform product and can be remotely located. The cost equipment used for this process is expensive. Fig. (**4**) shows that in this process, long, narrow piles are turned when required based on temperature and oxygen requirements. The only disadvantage of this process is it can have odor problems, and when it is exposed to rainfall, it can create leachate problems [10].

CHAPTER 6

An Application of EJSCREEN for the Examination of Environmental Justice in Metropolitan Areas of Ohio, USA

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Abstract: Over the past few decades, the notion of Environmental Justice (EJ) in the United States has grown. Many empirical studies prove how low-income and minority neighborhoods are excessively exposed to environmental burdens. This chapter aims to present an approach to identifying EJ concerns facing minority and low-income populations in the metropolitan areas in Ohio by analyzing their distribution using EJSCREEN, a screening and mapping tool developed by the USEPA. Twelve metropolitan areas were considered to examine environmental and demographical information. The metropolitan areas are integrated geographic regions comprised of at least one city or urban area and adjacent communities. In assessing the demographic inequalities and environmental risk in the regions of the metropolitan areas, the EJSCREEN tool was used to generate EJ standard reports for all the zip codes in the metropolitan areas. Two-sample t-test results indicate that diesel PM, hazardous waste, RMP sites, lead paint, traffic proximity, respiratory hazard risk, and air toxic cancer risk are significantly higher in areas where a higher proportion of low-income and minority populations live than the areas with a lower proportion with low-income and minority populations. These environmental indicators are directly associated with air pollution.

Keywords: EJSCREEN, Environmental Justice, Metropolitan Areas, Ohio, Statistical Analysis.

INTRODUCTION

According to the United States Environmental Protection Agency (USEPA), “Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, concerning the development, implementation, and enforcement of environmental laws, regulations and policies” [1]. Fair treatment means every person in the community

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have an unbiased fair share of the negative environmental consequences resulting from the policies and operations of industrial, governmental, and commercial sectors. People can participate in decision-making activities that may affect their environment/health. The contribution of the public can influence the regulatory agency's decision. The queries/concerns from the communities will be considered in the decision-making process. Decision-makers will facilitate the involvement of those potentially affected [2].

Environmental justice revolves around people residing in a city/any place in different communities. This differentiation comes with people of different races, wealth, languages, and different ethnicity [3]. High-income communities have access to nutritious organic food and are often far away from the emitting pollution-emitting freeways. However, the case is different for the low-income; even if nutritious food and other facilities are available, they are unaffordable. Minority people are exposed to industrial sites, polluted ports, highways, and sometimes hazardous waste. To run the essentials of a city, pollution is created in terms of air, water, and land. So, these differences make people breathe unhealthy air, drink polluted water, and live near toxins (Fig. **1**) [4]. In simple terms, even if all the communities live in the same city, they lead a very different life from each other.

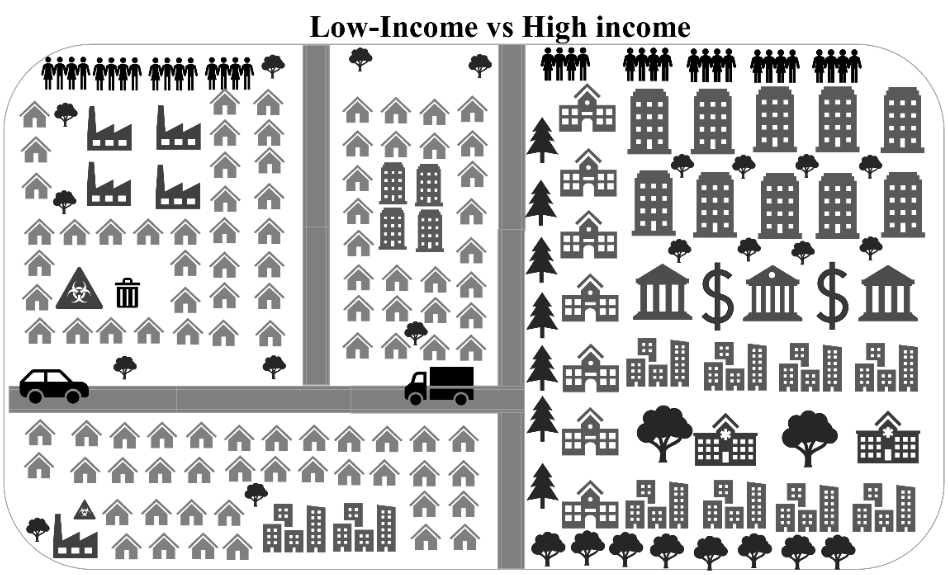

Fig. (1). A sample representation of a lack of environmental justice in a metropolitan area.

Most recent environmental injustices in the US have shown that vulnerable neighborhoods with a higher percentage of minority people are more likely to be exposed to more pollution, the placement of pipelines and factories, and the ongoing coronavirus disease since 2020. A growing number of proposals have been passed or are under consideration across the country that explicitly addresses the issue of "Environmental Justice." The pandemic has further highlighted the importance of addressing environmental and health inequities.

This chapter presents a simple approach to analyzing EJ issues related to an area or industry. The software developed by the USEPA is applied to get primary data for further analysis of the EJ issue. It is hoped that this chapter will motivate other environmental professionals to examine the EJ in their communities.

LITERATURE REVIEW

Generally, the facilities emitting toxic pollutants and landfills were in the places of poor, minority and low-income people reside. The people living in these communities have low meager protection from the toxic pollutants released from the facilities. Environmental justice took its origin in establishing the equalities between race, income, and nationality. There shouldn't be any bias against the poor or minority communities getting exposed to the toxins from industrial facilities. The environmental justice revolution started in the United States with the encountered incidents in 1982 (North Carolina), Warren county residents protested against dumping industrial waste in their community [5]. Later USEPA identified four landfills located in similar districts where minority people reside. In 1987, a report from the United Church of Christ stated: "the presence of hazardous wastes in racial and ethnic communities throughout the United States" [6]. In 1992, President George H.W. Bush founded the office of environmental justice in the USEPA [7]. In 1994, President Bill Clinton signed the executive order to address "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." Still, it was not made a law in congress [8]. In 2001 George W. Bush shifted the focus of environmental justice from Low Income & Minority Communities to All Vulnerable People [7]. In 2009, President Barack Obama's administration supported environmental justice initiatives that assess climate change vulnerabilities and developed regional solutions, and identified innovative ways to help the most vulnerable communities to prepare for the impacts of climate change through "Environmental justice progress reports (Executive Office of the President, 2013). Former EPA Administrator Lisa P. Jackson established environmental justice as an agency-wide (USEPA) priority. The EJ 2020Action Agenda is EPA's strategic plan for advancing environmental justice for the years 2016-2020, building on the work of Plan EJ 2014. This plan consists of eight priority areas and four significant

CHAPTER 7

Comparative Adsorption Study of Acid Violet 7 and Brilliant Green Dyes in Aqueous Media using Rice Husk Ash (RHA) and Coal Fly Ash (CFA) Mixture

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Abstract: One of the concerns in wastewater pollution is the presence of colored compounds, such as dyes. Acid violet 7 (AV7) and brilliant green (BG) are examples of synthetic dyes that have been used in various applications. In this work, a comparison of AV7 and BG dye adsorption was investigated using an adsorbent prepared from the mixture of rice husk ash (RHA) and coal fly ash (CFA). The attention was focused on the major batch adsorption parameters, which include adsorbent dosage, initial dye concentration, contact time, pH, shaking speed, and temperature. A lesser amount of RHA-CFA adsorbent was found to be used for adsorbing the same concentration of BG as compared to AV7. In contrast to AV7, the adsorption of BG rapidly attained equilibrium. The effective pH for BG removal is in the pH range of 6–8, while the highest AV7 removal was obtained at a low pH value. The adsorption removal for AV7 and BG increases with rising shaking speed and temperature. Scanning electron morphology (SEM) analysis showed the morphological porous structure on the RHA–CFA adsorbent surface. X-ray diffraction (XRD) analysis indicated the presence of complex compounds containing cristobalite, quartz, and mullite compounds in the RHA–CFA adsorbent. The study revealed that RHA–CFA adsorbents can remove AV7 and BG from an aqueous medium.

Keywords: Acid violet 7 (AV7) dye, Adsorbent, Brilliant green dye, Coal fly ash, Rice husk ash.

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INTRODUCTION

Population growth and the development of many types of industries have led to different kinds of environmental pollutants. One of the largest environmental problems encountered by cosmetics, dyestuff, textile, and related industries is water pollution attributed to organic dye usage [1 - 3]. More than half of the commercial synthetic organic dyes come from textile-related industries, and approximately 100 tons of effluent from these industries are discharged yearly [4].

Acid violet 7 (AV7) and brilliant green (BG) dyes are among the commercial synthetic dyes that have been widely used. AV7 dye belongs to the azo group and comprises aromatic, amino, and sulfonic groups in their structure, causing higher recalcitrant and genotoxicity compared with other azo dyes [5, 6]. Fabbri *et al*. [7] stated that the structures not adjacent to the azo bond showed high reactivity. Theoretically, the increasing number of azo groups lowers the decolorization capabilities of dyes. The usage of azo dyes in textile dyeing is extensive because of their superior fastness on the applied fabric, high photolytic stability, and resistance to microbial degradation [8]. Meanwhile, BG dye is categorized as a basic dye because it involves a high brilliance and intensity of colors and is highly visible even at a remarkably low concentration [9]. BG is a sulfate of di-(--diethylamino) triphenyl carbonyl anhydride [10] that presents a complex chemical structure. Both dyes are associated with a stable and complex structure and are simultaneously linked to carcinogenic, mutagenic, and neurotoxicity characteristics. Thus, the removal of these dyes is necessary because they can threaten water organisms, whereas their redundancy can alter the native color of the receiving water.

Hence, dye-containing wastewater must be treated before it is released into receiving water to prevent the aforementioned consequence. Many technologies have been developed for the treatment of dye-containing wastewater. Adsorption is among the methods that has been adopted for AV7 and BG dye removal. Previous studies showed that activated carbon is the best adsorbent. Regardless of their wide use for the removal of dye-containing wastewater, exploration of low-cost adsorbents prepared from agricultural and industrial wastes has been widely investigated for activated carbon substitution.

In Malaysia, rice husk ash (RHA) and coal fly ash (CFA) are among the examples of abundantly obtainable solid wastes generated from the combustion process at high temperatures of rice husk and coal in the rice mill and coal-fired power plant industries, respectively. The RHA was collected from the dust collection device attached upstream to the stacks of rice husk-fired boilers and furnaces [11]. Rao *et al*. [12] stated that approximately 22% of husk is produced from 1000 kg of paddy and milled rice and approximately 25% of husk weight is converted into ash during the combustion process. More than 43 million tons of RHA are expected to be generated worldwide based on the aforementioned conversion and paddy rice production statistics in 2018 [13]. Meanwhile, Malaysia alone generates almost 150 thousand tons of RHA. The disposal in landfills or open fields can be problematic and may cause serious environmental and human-health related problems due to the low bulk density of RHA [14]. Concurrently, coal-fired power plants in Malaysia have produced a considerable amount of coal fly ash (CFA) of approximately 6.8 and 1.7 million tons of coal bottom ash annually [15].

RHA and CFA have been utilized in many applications and possess satisfactory adsorption capability in removing many types of dyes. However, almost all investigations only adopted one form of ash, either RHA or CFA. The effect of the preparation of RHA–CFA mixture was recently addressed by using three different methods (*i.e*., reflux, magnetic co-precipitation, and magnetic template) for the removal of AV7 and BG dyes [16]. The optimum RHA–CFA adsorbent preparation condition was also investigated by using response surface methodology (RSM) and artificial neural network (ANN). Current studies showed that 2nd-order RSM and ANN models can be applied to predict and optimize the efficiency of RHA–CFA adsorbent toward dye-containing wastewater [17]. In continuation of the current study, investigating the influence of various parameters affecting RHA–CFA adsorbents is important. Parameters, such as pH, the initial concentration of solute and sorbent, agitation speed, temperature, and contact time, were usually studied in batch adsorption.

This study is crucial due to the absence of available information regarding the effects of various parameters for this kind of adsorbent during batch AV7 and BG dye adsorption. The current study also helps define the performance of RHA–CFA adsorbents. Furthermore, the extent of AV7 and BG dye removal significantly varies for different types of adsorbents, and the effects of various parameters reported in the literature are also inconsistent. Hence, performing a thorough study on this issue is useful. Thus, the effects of adsorbent dosage, initial dye concentration, contact time, pH, shaking speed, and temperature on the adsorption efficiency of RHA–CFA adsorbents toward dye were studied in the present work. The adsorption efficiency of RHA–CFA adsorbents for the removal of AV7 and BG dyes from aqueous solutions in a batch process is also quantified and compared. In addition, the prepared and spent RHA–CFA adsorbents were characterized by X-ray fluorescence (XRF), scanning electron microscopy (SEM), Fourier transform infrared (FTIR), and X-ray diffraction (XRD) to assess changes due to AV7 and BG dye adsorption.

CHAPTER 8

Pollution Prevention Assessments: Approaches and Case Histories

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Abstract: The pollution prevention (P2) approach known as source reduction is being used worldwide to reduce the deleterious effects on human health and the environment due to the contaminants released from a variety of industrial sources. This chapter focuses on the concept of pollution prevention approaches undertaken by the U.S.EPA. P2 approach is discussed by applying the concept of energy efficiency, energy savings, greenhouse gas emission (GHG) reductions, waste reduction, and stormwater management to local schools, restaurants, hospitals, and the industrial sector in Ohio, USA. Several publicly available tools were used to analyze data collected during assessments. The major tools used are the Energy Assessment Spreadsheet tool (developed by Air Pollution Research Group at the College of Engineering, The University of Toledo, Ohio, USA) for the energy savings and Economic Input Life Cycle Assessment tool (developed by researchers at the Green Design Institute of Carnegie Mellon University) for the estimation of environmental emissions from industrial activities.These approaches result in the reduction of financial costs for waste management, cleanup, health problems, and environmental damage. Outcomes of pollution prevention activities are knowledge-based, behavioral, health-related, or environmental, which includes decreased exposure to toxins, conservation of natural resources, decreased release of toxins to the environment, and cost savings. The chapter presents case studies that focused on energy, greywater reuse, and food waste diversion from landfills.

Keywords: Approaches, Assessment, Pollution prevention, Case studies, Cost savings, Energy savings, Industrial facilities, USEPA, Wastewater.

INTRODUCTION

The concept of reducing or eliminating pollution at the source is called pollution prevention also known as P2. Considering the impact on the environment along with the amount of money, time, and resources involved in the disposal of waste generated, the USEPA encouraged the industry to apply the P2 approach to reduce

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the release of contaminants to air, water, and land media [1]. The amount of waste to be treated, controlled, and disposed of is less when there is a decrease in the amount of pollution produced. The reduced pollution, which is covered in pollution prevention activities, also implies a low risk to public health as well as the environment. Pollution prevention activities were carried out in these industries like reducing pollution at the source by modification of manufacturing processes, switching to eco-friendly maintenance use chemicals, following conservation practices [2]. All kinds of pollution-generating activities can implement these pollution prevention approaches, which include the energy, agriculture, consumer, and industrial sectors. Pollution prevention reduces both financial costs, including waste management & cleanup, and environmental costs and costs associated with health problems & environmental damage [3]. One of the main advantages of P2 is to protect and conserve the environment by optimal use of natural resources. They also strengthen economic growth by improving ways for efficient production following eco-friendly alternatives in the industrialfacilities [4]. These activities help households, businesses, and communities to handle the waste. Knowledge-based, behavioral, health-related, or environmental targets are the outcomes of pollution prevention activities. They have decreased exposure to toxins, conservation of natural resources, decreased release of toxins to the environment, energy, and cost savings [5].

The way each industrial facility operates varies with the type of facility they fall under. Examples of different types of facilities are food processing, manufacturing, automobile, furniture, chemical, universities, laboratories, *etc.* The amount and type of waste generated and pollution created also vary. But the P2 approach stands first in the place where reduction of pollution at the source. This approach is the most preferable and most efficient way to reduce pollution [6]. (Fig. **1**) represents the waste management structure for pollution generation activities that need to be preferred in the industrial, agricultural, energy, consumer, and federal sectors to control pollution, according to the Encyclopedia of Chemical Processing [7].

The USEPA is creating awareness by educating the people through its resources about the importance of P2, laws, and policies created, actions taken by EPA through websites, conferences, webinars, training workshops, *etc.* The EPA funds different programs (*e.g.*: Pollution Prevention Grant Program and Source Reduction Assistance Grant Program (SRA)) [8, 9] to assist the local industrial facilities freely and implement pollution prevention approaches. National Emphasis areas (NEAs) are program priorities for the P2 program.

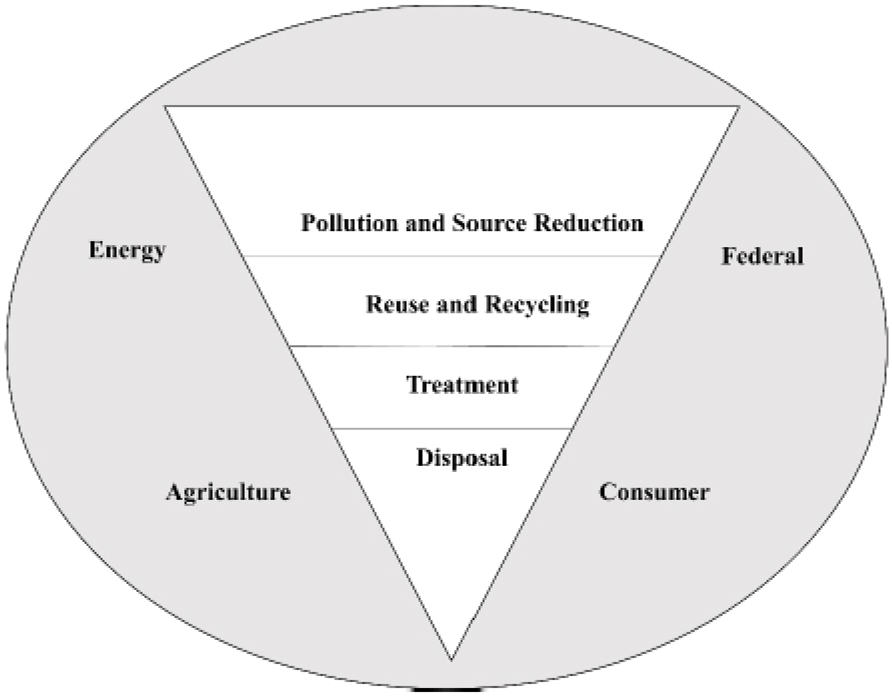

Fig. (1). The waste management structure for pollution generation activities.

POLLUTION PREVENTION

What is P2?

According to the Pollution Prevention Act of 1990, P2 is defined as "Any practice that reduces the amount of any hazardous/toxic substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment including fugitive emissions before recycling of discarded material, treatment, or disposal; and reduces the hazards to public health and the environment associated with the releases of those substances, pollutants or contaminants" [7]. P2 approach comprises practices that increase the efficient use of water, energy use, or use of raw materials, or taking other actions that protect natural resources before recycling, clean up or disposal and practices that may protect natural resources through conservation methods, or in-process recycling (*i.e.*, process improvements to reuse materials within the same business/ facility in the production process) [9].

CHAPTER 9

Industrial Biofilter Design for Removal of Hydrogen Sulphide (H_2S) from Wastewater Treatment Plants

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Abstract: Hydrogen sulphide (H_2S) is the main odor-causing, toxic, and corrosive chemical found in wastewater treatment operations. Bio-oxidation based processes for air pollutant removal have become more attractive to the industry and numerous wastewater treatment facilities have replaced conventional air treatment technologies such as adsorption and chemical scrubbing with bio-oxidation based processes such as biofilters. Of the three main types of air phase bioreactors, biofilter is used more commonly than the others due to its simple configuration, ease of operation, and economic benefits. This chapter addresses challenges in the industrial biofilter design for H_2S removal from wastewater treatment facilities. Wastewater industry professionals, biofilter customers, biofilter vendors, and researchers who work in the field of odor and H_2S emission control and biofilter design will find this chapter very useful.

Keywords: Hydrogen sulphide (H_2S), Odor control, Biofilter design, Air pollutant, Wastewater treatment emissions.

INTRODUCTION

The wastewater at conventional treatment facilities comes from many sources with different wastes and flow characteristics. During the multi-step treatment process, the amount of pollutants in the water is reduced to permissible limits. The emission of hydrogen sulphide (H_2S) is prevalent at various concentration levels throughout the wastewater treatment processes including preliminary treatment, primary sedimentation, biological treatment, secondary sedimentation, and sludge processing. Carrera-Chapela *et al*. (2014) report that odor contribution due to H_2S emissions at wastewater treatment facilities is in the following order: sludge stor-

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age (26%), sludge thickening (19%), sludge dewatering (17%), aerated grit chamber (13%), primary sedimentation (11%), aeration tank (5%), secondary sedimentation (5%), and bar screen (4%).

H_2S is a toxic and corrosive pollutant associated with several health effects including headaches, nausea, eye irritation, paralysis, and even death when exposed to high concentration levels. Wastewater treatment plant operators are recurrently exposed to H_2S. In a recent study, H_2S exposure levels are mapped to sewer works with regard to the types of jobs, tasks, seasons, and geographical locations (Austigard *et al*., 2018). The odor threshold of H_2S is in the range of 0.7–200 $\mu g/m^3$ and it is recommended to maintain the levels at or below this limit to avoid complaints from neighbouring communities (Godoi *et al*., 2018). H_2S emission is also a big nuisance due to its rotten egg odor characteristics; thus, strict regulations are in effect for the removal of this highly odorous and toxic gas at wastewater treatment facilities.

Conventional treatment methods such as condensation, carbon adsorption, chemical oxidation, scrubbing and incineration can be used for controlling air emissions (Barbosa and Stuetz, 2013); however, there are many disadvantages of these technologies which include high disposal cost, chemical use, and energy cost. The condensation is economical for only high boiling point compounds and more concentrated (*i.e*. high level of pollutants) air streams. The adsorption process is effective when the concentration of the pollutant is low. Spent adsorbents after several regenerations become solid waste that needs to be landfilled or incinerated. In scrubbing, pollutants are absorbed into scrubbing chemicals.

Chemical costs are high and the generated liquid waste requires further treatment. Incineration or thermal oxidation is widely used by many industries due to its high efficiency. However, due to high-energy usage (or fuel consumption), incineration is not economical when concentrations levels are low. Furthermore, the highest amount of greenhouse gases (GHGs) such as carbon dioxide and NO_X is produced by incineration. Biological processes also can produce greenhouse gases such as N_2O and CH_4. Furthermore, chemical oxidation and incineration are less effective when H_2S is present at low ppm (parts per million) levels in the contaminated airstreams.

In the last two decades, bio-oxidation based process units such as biofilters, bio-scrubbers and bio-trickling filters have become more attractive to industry (Rabbani *et al*., 2016). Hence, these units have replaced conventional technologies for air treatment at numerous wastewater treatment facilities. In a review paper, Mudliar *et al*. (2010) report that the biological waste air treatment using bioreactors has increased popularity in the control of volatile organic compounds (VOCs) and odors, since they offer a cost-effective and environment-friendly alternative to conventional air pollution control methods.

Of the three types of bio-reactors mentioned, biofilter is used more widely than the others due to its simple configuration, ease of operation and economic benefits (Barbosa and Stuetz, 2013; Shareefdeen and Singh, 2005). Other biological methods such as activated sludge diffusion (ASD) used for H_2S removal has limited application (Barbosa and Stuetz, 2013). The objective of this chapter is to provide practical guidelines based on sound knowledge of the industrial biofilter design for the removal of H_2S from wastewater treatment facilities.

Industrial Biofilter Design

Biofilter Configurations

Biofiltration takes place in an air-phase biological unit in which an air stream contaminated with pollutant is passed through a bed of media particles which are placed in a housing in the shape of a rectangular or circular tank or in a custom-made concrete structures depending on the size of airflow volume treated. As the air passes through a bed of medium, the pollutant such as H_2S, is transferred from the air phase to biofilms which are formed on the interior and exterior surfaces of the packing media particles. The metabolism of the pollutants by bacteria requires a moist environment; thus the moisture is provided by saturating the incoming air and by an occasional spray of water on top of the biofilter media. One of the important pre-treatment units for biofiltration is the humidifier. A simple configuration of a biofilter system is shown in Fig. (**1**). In biofilter design, many factors need to be considered.

Airstream Characterizations

Airstream needs to be characterized to find out the types of contaminants, concentration levels, temperature, humidity, and particulate levels (*i.e*., dust, aerosols) and other contaminants in the air streams. Based on the air stream characterization, one needs to determine if pre-treatment steps are required. If non-biodegradable compounds are present and they are odorous or toxic, these compounds need to be removed by physical or chemical methods through chemical scrubbers or other applicable air pollution control devices. It is important to consider that the selection of pre-treatment methods does not interfere overall biofiltration process.

Biofiltration is effective and economical for biodegradable odor-causing compounds such as hydrogen sulphide (H_2S) and VOC contaminants at low

CHAPTER 10

Assessment of Ground Water Quality Using GIS Techniques

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Abstract: In the present study, the groundwater quality was tested around the Gandhinagar sub-watershed covering a neighborhood of 53.63 sq. km, which lies between north latitudes 12°46′ and 13°58′ and east longitudes 77°21′ and 78°35′ within the state of Karnataka, India. For the study, data collection includes maps, toposheets, water quality data, well locations, village locations, *etc.* The above-said data has been collected from various government departments of Karnataka. After the data collection, the base map was prepared using ArcMap. The water samples have been tested and then used as an attribute database to design thematic maps showing various water quality parameters.

Keywords: Arc GIS, Groundwater quality, Quality parameter, Thematic maps.

INTRODUCTION

In the current scenario, in most of the cities in India, the water demand is met by groundwater utilization, as the surface water is either polluted or deficient. Groundwater is the primary source in India for domestic use and agriculture and the industrial sector (Umamaheswari *et al.*, 2015) [1]. In the present scenario, 85% of household water requirements in rural areas, 55% of farmers' irrigation water requirements, 50% of domestic water requirements in urban areas, and 50% of process water requirements of industries are met by groundwater. Groundwater has been tapped for the past twenty years because of the increasing demand for water and water resources management. This leads to water scarcity. The groundwater level has been falling rapidly day by day. It is essential to start investigations oriented toward groundwater quantification and qualification, which can become the basis to form plans for its exploitation, management, and conservation.

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Freshwater sources include lakes, rivers, and groundwater. Groundwater serves as the primary water source in the urban environment, used for drinking, industrial and domestic purposes. In the past few decades, increasing anthropogenic activities, especially industrialization, have become a threat to humankind and the ecosystem. Improper waste management practices often lead to the degradation of groundwater, with attendant health and environmental implications. It was initially believed that the soil and sediment layers deposited above an aquifer acted as a natural filter that kept pollutants from the surface from infiltrating down to the groundwater. However, it has become widely understood that those soil layers often do not adequately protect aquifers, and groundwater is inherently susceptible to contamination from anthropogenic activities. Remediation is costly and sometimes not practical.

Generally, physiochemical and biological analyses assess groundwater quality (Fatombi *et al.*, 2012; Kulandaivel *et al.*, 2009; Senthilkumar and Meenambal, 2007) [2 - 4]. Hydrochemical analysis of groundwater can also be utilized for groundwater quality (Ranjan *et al.*, 2013) [5]. The geographic Information System (GIS) mapping technique is used for groundwater assessment and its utilization for drinking, irrigation, and construction needs (Ravikumar *et al.*, 2013) [6]. An estimate can be obtained to better understand groundwater by representing the data by ArcGIS Software (Thiyagarajan & Baskaran, 2013) [7]. Over some time, there is a possibility of groundwater quality changes due to hydrology and geologic conditions (Pandey and Tiwari, 2009) [8].

A study on groundwater quality analysis was carried out for Coonoor taluk in the Nilgiris district. A survey was conducted on Ground Water Quality mapping in the Municipal Corporation of Hyderabad using GIS techniques. There is a need for a specific strategy and guidelines that would concentrate on a particular part of groundwater management, which means protecting groundwater from contamination. This study aims to visualize the spatial variation of specific physicochemical parameters through GIS. This work's main objective is to assess groundwater quality using GIS based on the available physicochemical data from 14 locations in the Gandhinagar sub-watershed area. Quality maps were created to visualize, analyze, and understand the relationship between the measured points.

MATERIALS AND STUDY AREA

Study Area: Kolar, the golden city of the Indian state of Karnataka, is the headquarters of the Kolar district. It is located in the State's southern region and is the easternmost district of Karnataka State. The neighborhood is bounded by the Bangalore Rural district in the west, Chikballapur district in the north, Chittoor District of Andhra Pradesh in the east, and south Krishnagiri and Vellore district of Tamil Nadu. The Kolar district receives an average annual rainfall of 748 mm, and the mean daily minimum and maximum temperatures are 22.7°C - 38°C, respectively. The sub-watershed area covers around 25 villages. Gandhinagar sub-watershed is undulating too plain. The northern and eastern parts of the world, forming the valley of Palar Basin, are well cultivated. The overall elevation varies from 849 to 1130 m above the mean water level. The study area has different landforms, like hills, ridges, pediments, plains, and valleys (Fig. **1**).

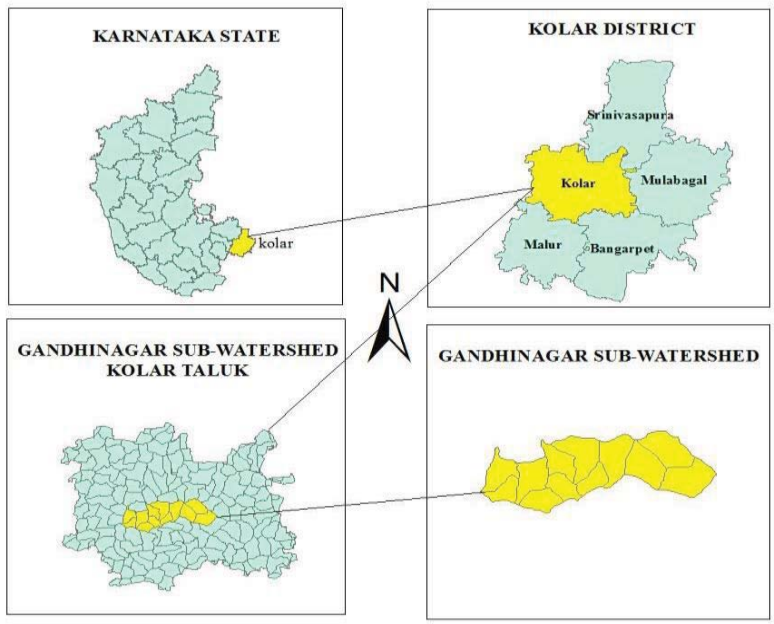

Fig. (1). Location map of gandhinagar sub-watershed.

SAMPLE COLLECTION AND ANALYSIS

The study area's base map was prepared using Survey of India topographic sheets (57G/15, 57G/16) and digitized using ArcGIS 9.3 software. Fourteen groundwater samples (Bore wells) were collected in April 2015. The groundwater samples were collected from 14 different bore wells in the Gandhinagar sub-watershed (Fig. **2**) in pre-cleaned, sterilized polyethylene bottles. The utmost care was taken to fill the bottles without air bubbles at each sampling site. The collected samples were labelled and transported to the laboratory using a refrigerator box. The reagents used in experimentation were prepared by using double distilled water.

CHAPTER 11

Threats to Sustainability of Land Resources Due to Aridity and Climate Change in the North East Agro Climatic Zone of Tamil Nadu, South India

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Abstract: Focusing on the erstwhile Chengalpattu district, north-east agro-climatic zone of Tamil Nadu region, this research aimed to assess the changes in spatio-temporal patterns and trends of the extreme climatic events and aridity conditions during the period 1971-2000. The trend analysis of the observed climatic parameters was carried out using R software and Mann-Kendall non-parametric test. A statistically significant increasing trend was noted in the warm spell duration (wsdi) and heavy rainfall events (r_{20}mm). The results revealed that Aridity Index (AI) has significant negative trends in northeast monsoon and winter seasons, indicating dryness, and positive trends in southwest monsoon seasons, indicating wet climate. The trends in MI were found to be mostly negative during the southwest monsoon season. The results of the trend analysis in PET revealed a significant increase annually and seasonally. Overall, spatial analysis characterized the western parts as semi-arid, whereas a dry sub-humid climate prevails in the eastern parts, covering the coastal areas. As per the outcome, there may be escalations of 19.5 to 25.7% in PE in the study area. Parts of Kancheepuram, Sriperumbudur, Chengalpattu, Thirukazhikundram, Maduranthakam, and the whole of Uthiramerur blocks are going to be severely impacted due to the rise of PE. This may further trigger an escalation of aridity processes in the future and pose threats to the sustainability of land resources.

Keywords: Aridity, Climate change, Land degradation, Land resources, Northeast agro-climatic zone, Sustainability, Tamil Nadu.

INTRODUCTION

According to the United Nations Convention to Combat Desertification, about 32% of India's land is being affected by land degradation. India stands strongly committed to implementing the UNCCD goals (National Report 2010) [1, 2]. In this context, research works involving regional and local assessment of the changing patterns of aridity deserve prime attention. Aggravations in the paridity

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conditions act as a stress multiplier in the context of global climate change [3]. The latest estimates of future climate change for India by IPCC (2013) project that there will be an increment of 5-10 days in the consecutive dry days as per emission pathway RCP 8.5 for the period 2081-2100 [4]. The rising frequency of dry spells and drought as a serious consequence of climate change was also reported in the earlier reports of the Intergovernmental Panel on Climate Change [5, 6]. Cruz *et al*. reported that the Indian subcontinent would be adversely affected by enhanced climate variability with rising temperatures and substantial reduction of summer rainfall in some parts, and associated acute water stress by the 2020s [7]. As per the predictions, the arid and semi-arid regions are going to be impacted severely by heavy land degradation, loss of biodiversity, and food insecurities [8, 9]. Water is going to be the major limiting factor for the healthy functioning of ecosystems, especially agriculture production worldwide [10, 11].

In general, several studies have been undertaken to analyze the trends in long-term precipitation and temperature, and its inter-annual, seasonal, and decadal variability at different time scales [10, 12 - 14]. Researchers have focused and extensively reported on regional aridity issues worldwide [15 - 18]. The findings from the analysis revealed that the sites which are currently at the limit with respect to available water resources, especially in semi-arid regions, are likely to be most sensitive to climate change challenges [19 - 23].

As per the UNCCD Report, 2001, dry lands are described as arid (excluding the polar and sub-polar regions), semi-arid, and dry sub-humid areas where the distribution of annual rainfall to potential evapotranspiration ratios falls within the range from 0.05 to 0.65 [9]. The arid and semi-arid regions comprise almost 40% of the world's land surfaces. The latest CMIP5 ensemble means future projections of RCP6 and RCP 8.5 emission pathways indicate a rise in the warming of about 3.3 to 4.8^{o} C by 2080s, relative to pre-industrial times [24]. A rise in the day time extreme temperatures, hot days, and increasing dryness have also been predicted for South Asian Regions [5, 6, 25].

India has been confronted with multiple challenges, from the rapid growth of population combined with drastic land-use changes and huge demand for food production. Under this circumstance, water scarcity may stand as a serious concern for agricultural production in arid and semi-arid areas of India due to its increasing over-dependency on the summer monsoon rainfall. NATCOM reports that climate stress is coupled with its unpredictability and inefficient irrigation Dev.elopments in our country [1]. Some researchers have established that teleconnections play a vital role in deciding climate change variability. Droughts events will have a strong link with the EI Nino-Southern Oscillation (ENSO) patterns [13, 26]. As per the Indian scenario, the recent drought of 2002 and 2004 suggests the inherent vulnerability of the Indian monsoon system due to the EI Nino phenomenon [27, 28]. In this study, the observed climate variables, temperature, rainfall, and PET have been utilized for analyzing the historical trends, aridity index, and moisture index. Apart from that simulation output of the Regional Climate Model, RegCM under RCP 4.5 emission trajectory has been utilized to provide a glimpse of the future likely PE for the study area.

MATERIALS AND METHODS

Study Area

Chengalpet (erstwhile known by this name), covering the present Thiruvallur and Kancheepuram district (Fig. **1**), forms part of the north-east agro-climatic zone of Tamil Nadu. It is situated between the latitudes 12° 0' 0" and 13° 40' 0" and longitude 79°0' 0" to 80° 20' 0". This area has a coastline of 115.1 km. The general slope of the study area is from northwest to southeast direction. The elevation of this area is between 100-200 meters.

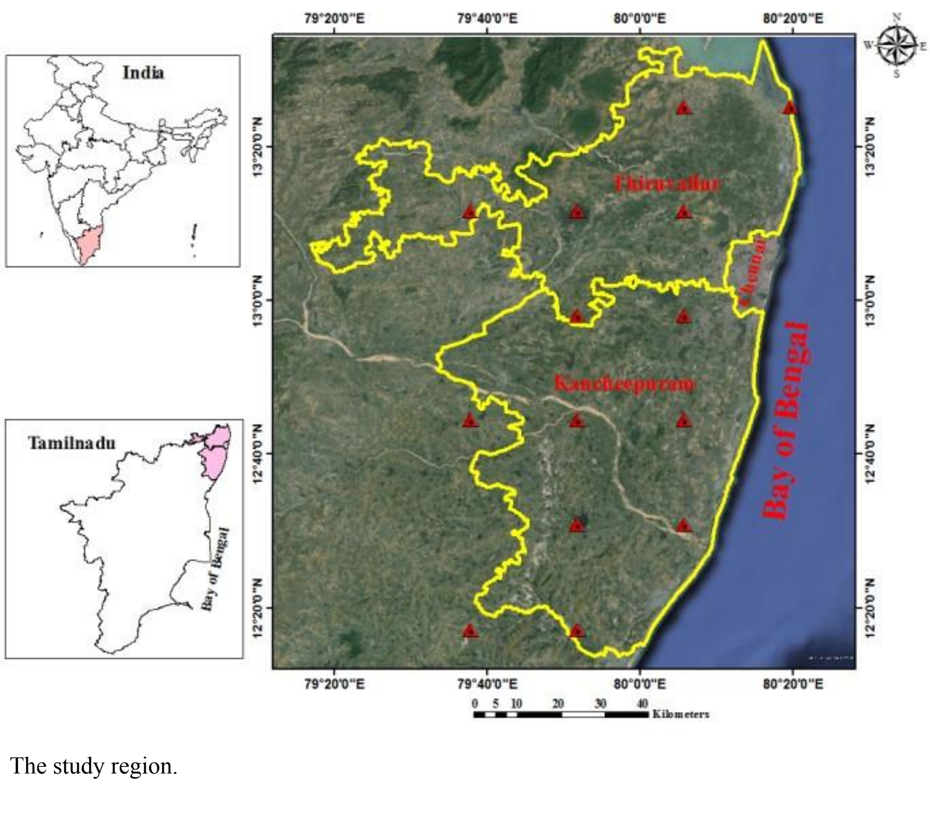

Fig. (1). The study region.

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