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RECENT ADVANCES IN GREEN TECHNOLOGY AND SUSTAINABLE DEVELOPMENT

Edited by
Dr. Prity Sharma
Mr. Chandan Singh

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1

An Eco-Friendly Soy Protein Isolate Film: A Review

C. Singh*
P. Sharma**

Introduction

The development of environmentally friendly and biodegradable materials from inexpensive or easily accessible natural and renewable resources, such as agricultural and food waste products, has drawn a lot of attention in light of the mounting environmental pressure brought on by plastic pollution and the depletion of oil resources. One of the most significant natural macromolecules is protein. Examples of proteins include collagen, milk, silk fibroin, egg, fish and keratin from animals as well as soy protein isolate (SPI) and wheat protein from plants. Because proteins contain polar functional groups, they can form a variety of bonds between molecules and have many different potential functional properties as an environmentally friendly membrane. [2–4]. Polymers (Natural/Synthetic) have emerged as an important research field for conferring superior properties on materials. Natural polymers can be obtained from natural resources such as plants, animals etc. Natural polymers are easily decomposable, ecofriendly, sustainable, low cost and help us to reduce the pollution. Soy protein is one of the most easily available biodegradable polymers. However there are some drawbacks such as low water resistance and mechanical properties that limits its application Researchers are committed to developing biopolymer-based film for use in packaging materials and coating industries because of the advantages over conventional petroleum-based materials. Plant proteins, like soy protein, zein, and wheat gluten, are among the many natural polymers that are gaining interest in scientific research and industry due

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to their affordability and ease of use. By using these proteins by products as biodegradable resins, environmental issues may be resolved and agricultural byproducts may gain additional value. Three types of commercial soy protein products are processed from soybean: soy flour (SF), soy protein concentrate (SPC), and soy protein isolate (SPI).Soy protein isolate (SPI) is a plant protein that is reproducible, safe, and biocompatible. SPI-based films have a wide range of potential applications in bioscience and biotechnology. Biopolymers produced from natural resources are regarded as an attractive alternate since they are renewable and biodegradable. Among biopolymers, soy protein isolate (plant protein) possesses high film forming abilities because of greater protein content.

In addition to playing a significant role in the traditional food, nutrition, and health care product industry, SPI is an edible, readily available, wearable, and degradable plant protein resource that also exhibits broader application prospects in the field of emerging materials, such as non-formaldehyde wood adhesive, biodegradable composites, and food packing material applications [5-7]. Unfortunately, soy protein materials' poor mechanical qualities and water resistance prevent them from being successfully used in a wide range of fields. Many attempts have been made, such as surface modification, chemical and physical cross-linking, and biomimetic structural design, to enhance the intrinsic qualities of soy-based materials. Although the prepared films' mechanical qualities and water resistance have improved, they are still far from ideal. Furthermore, SPI is unable to withstand high temperatures or strong acids or bases.

Table 1: Comparison of various Soy Proteins

Component (%)	Defatted Soy Flour	Soy Protein Isolate	Soy Protein Concentrate
Protein	52.0	92	65.3
Fat	5.0	-	0.3
Moisture	6.5	4.6	9.0
Ash	6.0	4.0	4.7
Fiber	3.0	0.25	2.9

Soy proteins material was further modified and characterized to improve mechanical properties, water resistance, and productive life which could facilitate the application of soy protein. Recently, soy protein based bio nanocomposites has proven to be a promising option in improving mechanical and moisture barrier properties. Soy protein based green composites show potential applications for housing, transportation and rigid packaging.

Composition of Soy Protein

A mixture of albumins and 119 globulins make up soy proteins; 90% of these are storage protein molecules with globular structures, primarily made up of 11S (glycinin) and 7S (β 120 conglycinin) globulins. Protein 122 fractions known as globulins have subunits connected by hydrophobic, hydrogen-bonding, and disulfide 123 bonds. Because amino acids have a large number of available active sites for molecular interaction, soy proteins are complex macromolecules made up of amino acids like cystine, arginine, lysine, hystidine, etc. About 18–20% oil, 40–45% protein, 25–30% carbohydrates, and 3% ash are found in soybeans [8-10]. From soybean processing 126 plants, soy protein is readily accessible in three different forms: soy flour (54% protein), soy protein concentrate (65–72% protein), and soy protein isolates (SPI, ≥ 90% protein). Soybeans, which have roughly 56% protein and roughly 34% carbs, are ground into very fine powder and then turned into soy flour. More than 65% protein and 18% carbs are found in soy protein concentrate, which is made by eluting soluble components from defatted 130 soy flour. With a minimal protein amount of 90% on a moisture-132 free basis, soy protein isolate (SPI) is a highly processed or purified form of soy protein. It is manufactured from defatted soy flour, which has had the majority of its 133 fats, carbohydrates, and non-protein constituents eliminated.

Film Formation Methods of Soy Protein

As of right now, there are two main methods for preparing soy protein materials: melt-processing-based (compression molding) and solution-based (solution casting). Below are the specifics of each procedure:

- **Solution Casting Method:** Based on the solubility or dispersion of proteins in a solvent medium, solution casting is the most widely utilized solution-based technique. The most popular dispersion medium for soy protein due to its hydrophilic nature is water. In order to prepare, you must first dissolve the polymer solution or nanoparticle dispersion in water, then combine it with the soy protein suspension. Finally, you must evaporate the water. Nonetheless, it limits the selection of hydrosoluble polymers (polyvinyl alcohol, agar, poly (ethylene oxide)) or polymers that can be dissolved in water as an emulsion or latex (polyurethane, polystyrene, natural rubber, etc.) for blending. Large volumes of hydrophobic polymers, like polylactic acid and polycaprolactone, did not show a common solvent for the hydrophobic/hydrophilic nature difference [11-15].The solution casting process uses a lot of energy, has low production efficiency, and could pollute the environment. Consequently, it is feasible to use in laboratories, but industrial use is limited. Furthermore, after they have dried, the cast films are frequently challenging to remove from the supports or substrates. It might be easier to remove the film if mold-release agents are sprayed on the structure before the solutions are cast.

The mixture of solutions could also be dried by lyophilization or by adding soy protein precipitant in addition to casting. To create a uniform dispersion, soy protein and nanofillers were broken up and combined with water. The mixture was freeze-dried or precipitant, like acetone, was added to produce the composite powders. The process of hot pressing in the presence of plasticizers was used to create the nanocomposite films or sheets. Protein blends made from soy were also created using this technique. For instance, the combination of SPI solution and natural latex rubber was successfully frozen and lyophilized to create SPI/natural rubber blends [16-18]. This method is expensive and has low production efficiency, much like solution casting methods.

- **Compression Molding:** Generally, soy protein based films are prepared by this method Melt processing is more feasible for industrial use than solution-based techniques, which require a lot of energy. This process encompasses injection molding, hot pressing, and extrusion. One of the main procedures in the plastics industry is extrusion. The polymeric solid material is moved by a screw during the extrusion process and melts as it passes through a die to create a continuous profile. The soy protein underwent a continuous plastic melt under conditions of extreme temperature, excessive pressure, and mechanical shear, which led to protein denaturation and a decrease in solubility. Compared to single-screw extruders, twin-screw extruders are significantly more capable of exchanging heat and have higher production efficiency. The primary factors affecting the dispersing effect are temperature, screw speed, and length/diameter ratio [19]. SPI powder is combined with various concentrations of plasticizers, such as Sorbitol and glycerol, in an electronic mixer for a predetermined period of time. The resultant mixtures are heated to a specific pressure and temperature and then hot pressed. So, the SPI films that have been plasticized are ready. In one study, Kumar et al. created polyfurfuryl alcohol reinforced SPI bio-films by dipping compression-molded SPI film in acid-catalyzed furfuryl alcohol. As long as the additives bind to the SPI, this is an additional way to include them in the prepared SPI films. It's crucial to combine solid additives with SPI in an electronic mixer when adding them to SPI. Compression molded SPI bio-films can be created by combining the resultant additives with SPI powder [20-21].

The qualities of the films created using the first two techniques were recently compared by Garrido et al. [22]. The SPI film's material properties can be greatly impacted by the manufacturing process. In particular, the SPI films made using the two methods differ in their mechanical, optical, thermal, and barrier properties. The films made through solution casting have a low water resistance and hydrophobicity. In contrast, films made by compression molding have a smoother surface, greater elongation at break, higher tensile strength, and higher transmittance than films made by solution casting.

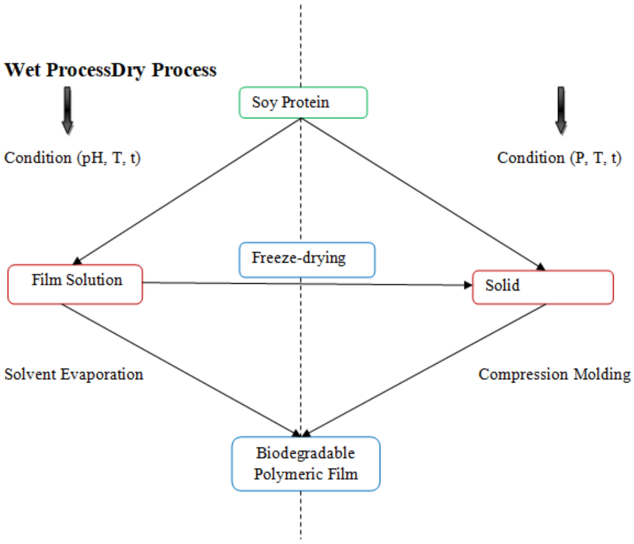

Fig.1: Polymeric Film (Soy Protein) Processing Schematic Diagram

Properties of Soy Protein Isolate Film

Strong intra and intermolecular interactions, including hydrogen bonding, dipole–dipole, charge–charge, and hydrophobic interactions, are present in soy proteins because they contain both polar and non-polar side chains. Soy protein films have higher stiffness, yield point, and tensile strength because of segment rotation and molecular mobility being restricted by the strong charge and polar interactions between side chains of soy protein molecules.

Several advantages have been identified for the use of soy-protein polymers. The manufacturing process is environmentally friendly because no toxic gas is created during processing soybean protein is abundant in the U.S. so the cost of original materials is low; and protein polymers are ductile and viscous.

- **Physical and Mechanical Properties**: After formation of soy protein based film, different physical and mechanical properties should be analyzed. Here we introduce some properties **(i)Thickness (ii) Surface Density (iii) Tensile Strength and Elongation**. The tensile strength was defined as the maximum strength in the stress–strain curve. The maximal strain was defined as the breaking strain. Young’s modulus was defined as the slope of the stress–strain curve in the elastic (linear) region. At least three samples were tested for each type of specimen. We looked at mechanical properties like load-at-break, maximum elongation, static strength, and elastic modulus. The most crucial characteristics of soy protein materials are their mechanical performance, particularly when they are utilized as structural materials. Tensile strength tests for films and sheets, impact tests for sheets, and compression tests for foam materials are the primary methods used in the characterization of protein-based materials. The influence of compression mechanical properties of foams was somewhat complicated. Besides those factors that affected the tensile strength of films or sheets, the density, cell morphology as well as the open cell content also endow the compressive strength and modulus of foams materials [Glycerin was found to reduce the brittleness of the protein polymer]. The polymer's modulus decreased while the polymers' elongation at break increased. The polymer changed to resemble rubber, becoming more viscous and ductile. As a result, the protein polymers' toughness needs to be considerably raised. Before mechanical investigation, Yufei et al. reported measuring the soy protein isolate (SPI) film improved with graphene's thickness using a digital micrometer. On the tensile strength testing apparatus, the mechanical characteristics were ascertained. Five duplicates of each film were used to calculate the tensile strength (TS), elongation at break (EB), and Young's modulus (E). While decreasing the EB, the incorporation of graphene increased the TS and E. The TS of SPI film, which contains 74% graphene, rose from 4.74 to 6.03 Mpa in comparison to the genuine SPI film, which explains the 27.22% increase. The results could be explained by the chains of SPI molecules deforming. A single layer of graphene was dispersed throughout the SPI matrix, which improved the interaction [23-25].

- **Thermo-mechanical and Functional Properties:** The behaviors of soy protein isolate during formation, processing, storage, and consumption is determined by their physico-chemical properties. These characteristics are crucial for determining the final product's quality as well as for making processing easier. It is common practice to use differential scanning calorimetry (DSC) to analyze the thermal characteristics of food proteins, including denaturation brought on by heat. The process of denaturation is an intramolecular alteration that results in the breakdown of internal order and, in certain situations, the total unfolding of peptide chains, leading to the creation of "random coils."

Other Properties

- **Optical Properties**

  (a) Light Transmission (b) Color

- **Barrier Properties**

  (a) Water Vapor Permeability (b) Oxygen Permeability

- **Chemical Properties**

  (a) Moisture Content (b) Film Solubility (c) Microstructure (d) Infrared Spectrum

Here we compile a comparison table of Tensile strength, Elongation at break and water vapor permeability of modified soy protein film [Table 2].

Table 2

Modified SPI Film	Tensile Strength (MPa)	Elongation at Break (%)	Water Vapor Permeability	Ref.
SPI/CMC	5.682 ± 0.397^{a}	131.421 ± 9.642^{b}	16.32 ± 0.94^{ab}(g·mm·m^{-2} · day^{-1} ·kPa^{-1})	26
SPI-CT	4.339 ± 0.242^{bc}	247.796 ± 26.209^{a}	15.93 ± 1.29^{b}(g·mm·m^{-2} · day^{-1} ·kPa^{-1})	26
SPI/CMC-CT	5.568 ± 0.287^{a}	140.446 ± 16.658^{b}	15.26 ± 0.57^{b}(g·mm·m^{-2} · day^{-1} ·kPa^{-1})	26
SPI-SW	8.53 ± 0.79^{a}	42.76 ± 13.8^{d}	3.75 ± 0.28^{d}(× 10^{-6}g·m/m^{2}·h·Pa)	27
SPI–CS	3.02 (0.28)^{b}	67.89 (3.29)^{c}	1.27 (0.19) ^{a}(g·mm·h^{-1} ·m^{-2} ·kPa^{-1})	28
SPI-CuNCs	3.55 (0.21)^{b}	17.05 (0.17)^{c}	0.99 (0.12)^{c}(g·mm·h^{-1} ·m^{-2} ·kPa^{-1})	28
SPI–CS–Cu NCs	5.01 (0.34)^{a}	30.84 (0.13)^{b}	1.10 (0.16)^{b}(g·mm·h^{-1} ·m^{-2} ·kPa^{-1})	28

Abbreviations

SPI/CMC: Soy protein isolate and carboxymethylcellulose film

SPI-CT: Soy protein isolate film with catechin

SPI/CMC-CT: Soy protein isolate and carboxymethylcellulose film with catechin

SPI-SW: Soy protein isolate film with sorghum wax

SPI–CS: Soy protein isolate film with chitosan

SPI-CuNCs: Soy protein isolate film with Cu nanoclusters

SPI–CS–Cu NCs: Soy protein isolate film modified with chitosan and Cu nanoclusters

Modification of Soy Protein for Film-Formation

- **Effect of Plasticizers:** To obtain the practical physical as well as thermo-mechanical characteristics for each final application, a fundamental step in the development of plastic materials is the appropriate selection of the plasticizers. Biopolymer-based materials' various interactions—such as hydrophobic, hydrogen bonding, and electrostatic—that may form between molecules during processing define their characteristics. Thus, in order to facilitate processability, plasticizers must be added during the formulation of these materials. Low molecular weight plasticizers have an effect of softening that enhances flow characteristics, makes it easier to incorporate additional ingredients (like fillers), and/or lowers the processing temperature of bioplastics. Furthermore, the existence of plasticizers is usually associated with a decrease in the amount of pores and cracks in the finalized material. Water, polyols, and mono-, di-, and oligosaccharides are frequently used in bioplastics, with the constant in mind that they should be compatible with the other ingredients [29-31].

- **Heat Treatment:** Two of the most significant factors in soy protein film processing are temperature and pressure, which work together to deteriorate the protein, unfold its massive structure, and allow for the interaction and the entanglement of protein modifications to alter the material's properties. As a result, the processing pressure and temperature used will have a big impact on intra- and intermolecular interactions. Warming soy protein dispersions to temperatures higher than 70° C causes the globular structure to unfold, denatured the protein and promoting the creation of new intra as well intermolecular bonds, such as hydrophobic or electrostatic ones. Heat treatment has the ability to denature soybean protein, causing unfolding and a disruption of intramolecular bonding. It is common practice to use differential scanning calorimetry (DSC) to analyze the thermal characteristics of food proteins, including denaturation brought on by heat. The process of denaturation is an intramolecular alteration that results in the breakdown of internal order and, in certain situations, the total unfolding of peptide chains, leading to the creation of "random coils." Heat treatment has the ability to denature soybean protein, causing unfolding and a disruption of intramolecular bonding [32-33].

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2

A Review Paper on UV-Visible Spectroscopy

Deepika Bansal[*]
Priyanka Meena[**]
Kartika Sain[***]

Introduction

Spectroscopy is the branch of science that deals with the study of interaction of electromagnetic radiation with matter. Spectroscopy is the most powerful tool available for the study of atomic and molecular structure and is used in the analysis of a wide range of samples. Spectroscopy is an instrument design to measure the spectrum of a compound.

Instrument used to measure the absorbance in UV (200-400nm) or visible (400-800nm) region is called UV visible spectrophotometer.

Principle

The principle of UV-Visible spectroscopy is based on the absorption of ultraviolet light or visible light by chemical compounds, which results in the production of distinct spectra. Spectroscopy is based on the interaction between light and matter. When the matter absorbs the light, it undergoes excitation and de-excitation, resulting in the production of a spectrum. When matter absorbs ultraviolet radiation, the electrons present in it undergo excitation .This causes them to jump from a ground state (an energy state with a relatively small amount of energy associated with it) to an excited state (energy state with are natively large amount of energy associated with it). It is important to note that the difference in the energies of the ground state and the excited state of ultraviolet radiation or visible radiation absorbed by it [1-2].

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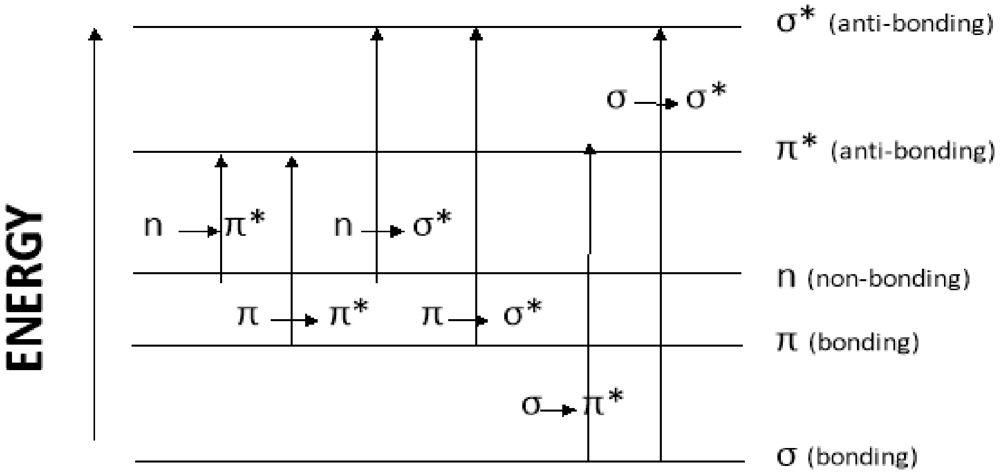
Theory

The absorption spectra arise from transition of electrons in a molecule. The possible electronic transition can be graphically shown as



σ → σ* Transition: σ electron is excited to corresponding anti-bonding orbital σ* . The energy required is large for this transition.

Example: Methane

π → π* Transition: π electron is excited to corresponding anti-bonding orbital π*.

Example: Alkenes

n → σ* Transition: The saturated compound containing atoms with lone pair of electrons like, Oxygen, Nitrogen, Sulphur and Halogens are capable for this transition. It requires less energy.

n → π* Transition: An electron from non bonding orbital is promoted to anti bonding π* orbital. It requires less energy.

σ → π* Transition: This transition are only theoretical possible.

π → σ* Transition: This transition are only theoretical possible.

Laws

Beer-Lambert Law: Beer-Lambert Law states that, "The absorbance (A) of monochromatic beam is directly proportional to concentration (C) and path length (L).

$A=\varepsilon C.L$

Where, A= Absorbance

ε= Molar absorption coefficient

C= Molar concentration

L= Path length

Limitations of Beer-Lambert Law

- When a ray of monochromatic light passes through an absorbing medium is intensity decreases exponentially as the length (L) of the absorbing medium increases.
- Changes in refractive index at high analyte concentration.
- Scattering of light due to particulates in the sample.

Instructions

- Light sources
- Monochromator
- Sample and reference cells
- Detector
- Recorder

Light Source: The light source used must provide consistent and stable light.

- Hydrogen and deuterium lamps
- Tungsten filaments lamps
- Xenon arc lamps

Monochromator: It separates polychromatic light into single spectral line. A monochromator is an optical device that is used to select a narrow band of a wavelength of light.

- Slit
- Mirror
- Lens
- Prism
- Grafting

Sample and Reference Cells: The cuvettes are generally made up of quartz and borosilicate.

One beam pass through sample solution and second beam pass through reference solution. The cuvettes are generally transparent.

Detector: The detector is responsible for detection of radiation. The intensity of radiation from references cell is stronger than beam of sample cell .

- Photovoltaic cell
- Phototubes

Recorder: The recorder detects and records the data of the experiment. It also stores the data in computer when it connected to computer.

Choice of Solvent and Solvent Effects

- The absorption bands in UV spectrum are very broad compared with IR/NMR.

- UV spectra of compounds are generally identified in vapor phase and dilute solutions.
- Solvent must be transparent.
- The solvent should not itself absorb radiation.
- The solvent should not react with solute molecules.
- The Ethanol (95%) is most commonly used solvent [3-5].

Advantages of UV-Visible Spectroscopy

- Wide application range of UV-Visible Spectroscopy is applicable to a wide range of substances, including organic compounds, inorganic compounds, transition metal complexes, and biological molecules like proteins and nucleic acids.
- Grating gives higher and linear dispersions compared to prism monochromator.
- Can be used over wide wave length ranges.
- Provide light of narrow wavelength.

Disadvantage of UV-Visible Spectroscopy

- Mixtures of molecules can be problem due to overlap (hence requires significant sample preparation).
- Spectra are not highly specific for particular molecules.
- Only liquid samples are possible to analyze.
- The results can be affected by Temperature, PH, impurities etc.

Application of UV-Visible Spectroscopy

- Detection of impurities.
- Structure elucidation of organic compound.
- It is used in DNA and RNA analysis.
- Quantitative analysis.
- Qualitative analysis.
- Dissociation constants of acids and base .
- It is used in drug identification.
- It is used in for determination of different species.
- Molecular weight determination.
- As HPLC detector [6-10].

Conclusion

If used with the right standard curve and applied to pure substances, UV-Visible spectroscopy is a reliable, straightforward, and affordable approach for estimating the concentration of absorbing species. One of the crucial methods for analyzing the optical characteristics of PMCs is UV vis spectroscopy. It clarifies the relationship between the matrix and the nanofiller and examines how the nanofiller contribute to the enhancement of the properties of the nanocomposites. To assess the intended optical properties of nanofillers in a polymer matrix, UV-Vis spectroscopy is a crucial technique. The polymer nanocomposites with some optically responsive nanofiller, such as metals, semiconductor nanocrystals, and nanooxides, are characterized using the UV-Visible spectroscopic approach in order to produce functional materials with significant technological applications. UV-Vis spectroscopy (or spectrometry) is a quantitative technique used to measure how much a chemical substance absorbs light. This is done by measuring the intensity of light that passes through a sample with respect to the intensity of light through a reference sample or blank.

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3

Review: Chromatography

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Introduction

Color writing is known as chromatography, but a more precise description is a physical separation method that allows a mixture of substances to be isolated, purified, and divided into distinct molecules that have varying rates of distribution based on 1. Solubility 2. Affinity between molecules (polar or non-polar) 3. Interaction with fixed material (the stationary phase, which we shall define later): The mixture's constituent parts are distributed between the stationary phase and the mobile phase, which travels in a predetermined direction at different speeds [1, 2]. The following three components are essential to any chromatographic separation technique: 1. Sample 2. Mobile Phase 3. The stationary state. Stationary phase: this solid substance, which can only be either solid or liquid by nature, is where the component mixture will be isolated and separated. A mixture consisting of a sample that needs to be isolated, purified, and separated at the surface of the stationary phase is known as the mobile phase [3]. The mobile phase can be either solid or liquid. Chromatography's primary goal is to bridge the gap between analytical methods, which ascertain a sample's concentration and chemical makeup, and primitive methods, which rely solely on separating and isolating mixture samples [4].

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Principle

The fundamental idea behind chromatography is that mixtures of molecules applied to surfaces or into solid, fluid stationary phases (stable phases) separate from one another as they move with the help of a mobile phase. Molecular properties associated with liquid-solid adsorption, liquid-solid partition, and affinity or variations in their molecular weights are thefactors that have an impact on this separation process. Some components of the mixture pass quickly into the mobile phase and exit the chromatography system faster than others due to these differences, while others remain in the stationary phase longer and move moreslowly [5].

Classification

Three categories can be used to categorize and condense the chromatographic methodtechnique:

- Be dependent on how the stationary phase is shaped for instance, column and planarchromatography.
- Rely on the fixed and mobile phases' respective physical states. For example, liquid andgas chromatography.
- Rely on how the mobile and stationary phases interact. For instance, size exclusion chromatography, partitioning, adsorption, affinity, and ion exchange [6].

Types of Chromatography

Paper Chromatography (PC)

Partition chromatography uses liquids for both the stationary and mobile phases; in a 2D plate, the stationary phase is the polar adsorbed water in the paper. Half an inch in from the filter paper's edge, the dissolving sample is deposited in a small location and allowed to dry. Depending on the mode of action ascending, which moves up along the paper, or descending, which moves down due to the high viscosity of thus mobile phase the dry spot will be held at the front end of a closed chamber saturated with atmosphere, and the end closer to the sample contacts the solvent, which moves up or down by capillary action. We eliminated the uncolored areas that had separated in the paper when the mobile phase mixture reached its full length, and we measured each separated zone using a suitable technique known as retention factor or rate flow (Rf) [7].

$$\text{Retention factor} = \frac{\text{Distance moved by solute}}{\text{Distance moved by solvent}}$$

In this, mobile phase is a polar substance, and the stationary phase is a non-polar one. Distance moved by solute Distance moved by solvent.

Thin Layer Chromatography

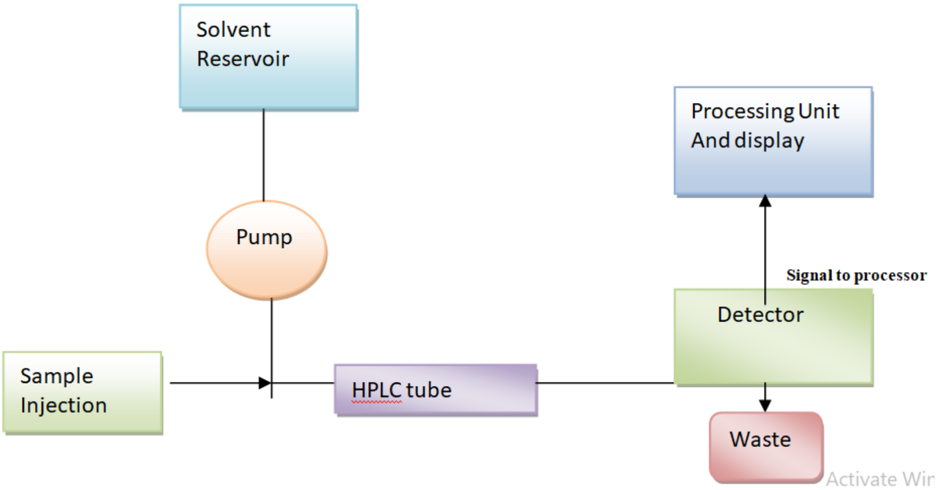
Solid-liquid adsorption occurs when the stationary phase in thin-layer chromatography interacts with a large surface area, with the mobile phase being liquid. Through the stationary phase a thin plate immersed in the solution capillary action forces the mobile phase upward. The substance's, solid phases, and solvent's polarity all influence this upward motion rate. As a result, we can employ a colored chemical substance the most popular of which is ninhydrin and the black light viewing approach to accept the color of the non developing thin plate to be developed and appear at chromatogram and identify as a separated peak each one [8]. The biological source of active substances and their metabolites, such as urine constituents like steroids, amino acids, porphyrins, and bile acids, can be purified by thin-layer chromatography, along with macromolecules like aromatic amines on silica gel layers, active ingredients, preservatives in drugs and drug preparations, and contributions to synthetic manufacturing processes. Furthermore, it uses cationic and non-ionic surfactant-mediated systems as mobile phases to separate a complex pharmacological component and identify pesticides [9].

Column Chromatography

A three-dimensional shape model, the column can have an open or packed tubular geometric structure. When densely packed, the stationary phase fills the wall and every available area in the column. However, the stationary phase is located at the column locations in the open tubular. Column chromatography is categorized by two primary international groupings as follows: 1. Liquid chromatography (HPLC) 2. Gas chromatography [10].

High-Performance Liquid Chromatography (HPLC)

Known as high-performance liquid chromatography (sometimes known as high-pressure liquid chromatography), HPLC is mainly predicated on the utilization of a packing material- filled column. (Stationary phase), a pump that moves the mobile phase or phases across the column, and a detector showing the lengths of time molecules are retained. The interactions of the stationary phase, the molecules under study, and the solvent(s) used control the retention time. Usually added to the stream of the mobile phase, the sample is slowed down by interactions with the stationary phase, either chemically or physically. During the analysis, the composition of the mobile phase is altered by gradient elution. The gradient separates analytic mixtures based on the analytic affinity for the mobile phase. The gradient, additives, and mobile phase selection are influenced by the characteristics of the sample and the stationary phase [11].



Applications

- From finding the optical isomer to figuring out how much mixture is in a sample, chromatography has become extremely important in the study of chemistry [12].
- The different inks or dyes are extracted from the mixture using paper chromatography [12].
- Gas chromatography is used to detect the presence of alcohol or certain other substances in blood or urine [12].
- In order to identify adulterants [13].
- Help in detecting pollutants in food and drinks [13].
- Assistance with cosmetics analysis [13].

Conclusion

The conclusion is that every kind of chromatographic separation technology has a wide range of highly effective, sensitive, and important applications in the industrial, clinical, and majority of human sectors. Chromatography techniques increase the productivity of chemicals and instruments by providing more information because of their increased sensitivity, speed, and resolution. It is possible to drastically cut down on the amount of timeneeded to refine new techniques.

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4

Electronic Waste Management: Issues and Strategies

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Introduction

The largest and fastest-growing manufacturing industry in the world is electronics. It has been significant in the socio-economic and technological growth of societies in the past several years. Equipment used for data processing, communication, entertainment, and commercial purposes makes up the majority of electronic trash, also known as waste from electrical and electronic devices [1]. The term "e-waste" refers to electronic components that have been used and are expanding quickly as a result of the increased global use of electronic items. Due to cost reductions and expanding internet usage, as well as developments in telecommunications and information technology, there is a growing requirement for electronics parts. The rapid rise in production and consumption in the electronics sector is the reason behind the increase in both the quantity and toxicity of e-waste in India [2]. Hazardous substances such as cathode ray tubes, also called cathode ray (CRTs), that consist of oxides of hazardous metals, can contaminate soil and groundwater when they are discarded. If a suitable system of management does not exist for the treatment of e-waste, it poses serious risks to both humans and the environment. Recycling electronic waste and recuperating resources are major problems due to their hazardous nature. Nevertheless, only a small percentage of e-waste is properly collected and regained; the rest is dumped in graves and transferred to black markets. E-waste is frequently imported by countries that are emerging without adequate preparation or effective management [3]. Because of this, the

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majority of these wastes are either kept in storage by outmoded recycling firms or wind up in municipal landfills. While the recovery of resources from e-waste could bring about employment and commercial possibilities, inadequate infrastructure and ineffective scientific methods can hinder the management of this resource [4]. By products from unofficial e-waste recycling techniques include furans, dioxins, and heavy metals [5].

Classification of E-Waste

It is feasible to categorize electronic waste according to its elements and material. Glass, plastics, metallic and non-metallic and other harmful substances constitute the content of e-waste [6]. Plastic materials constitute the biggest percentage of e-waste. The second most common type of material are metals and non-metals. Both types of materials are highly valuable commercially. Based on European Union directives, which classify e-waste into the ten groups outlined below, one of the most frequently employed categories is the following:

- Large domestic appliances such as cooling systems, microwaves, electric ventilators, refrigeration units, laundry machines, clothes dryers, washers and dryers, and electric skillets and cookware [7].
- Portable home appliances: air filters, toaster ovens, coffee makers, coffee grinders, and equipment for shaving, brushing, and hair drying.
- Communications devices, including cell phones, wireless phones, printing machines, computers, laptops, notebooks, mainframes, and notebook computers.
- Items of consumer electronics, such as audio amplifiers, TVs, radios, digital cameras, stereo tape recorders, and musical devices [8].
- Lighting apparatus, including high-intensity discharge lamps and straight, compact LED bulbs.
- Electric tools such as cutting instruments, drills, sewing machines, welding tools, and apparatus for processing metal and wood through processes such as stretching, bending, crushing, and drilling.
- Games, sports products, and entertainment items: video games, electric train or motor car sets, and electric sports equipment [9].
- Pharmaceutical devices: analyzers, respiratory ventilators, cardiology, dialysis, nuclear medications, and radiation equipment.
- Thermal regulators, heaters, and smoke sensors are examples of monitoring and control devices [10].
- Automatic dispensers: these include all gadgets that automatically dispense different products.

Effects of E-waste on Health

E-waste, or used electrical and electronic devices and components, is one of the waste sources that is expanding the fastest around the globe [11]. A large amount of e-waste is thrown away in landfills, however a number of components can be recovered through reprocessing. E-waste exposure can happen in two ways: directly through reprocessing or secondarily through environmental exposure [12]. Recycling of e-waste can result in high levels of environmental pollution, which exposing residents to the danger of ecological exposure through polluted food, water, and ambient air sources [13]. Therefore, workers and residents could be exposed to complex combinations whose toxicology is unknown, even though the toxic effects of the original elements may be recognized [14]. Despite the lack of reliable facts, concerns about the health impacts of the chemical consumption of e-waste and e-waste recycling are increasing [15]. Adverse effects that have been reported include genome damage, unusual thyroid gland function and development, neurobehavioral problems, premature delivery, and congenital disorders. Still, not much direct research has been done [16]. Most susceptible are young babies and developing embryos, and there is increasing evidence that being exposed to the environment might have negative early-life effects.

Effects of E-Waste on the Environment

Improper handling of electronic waste can be a factor that contributes to climate change. When raw materials are taken out and cleansed from waste, atmospheric greenhouse gases are released [17]. Greenhouse gases that increase the temperature of the earth include CFCs, which are generated by coolants and other climate-exchange devices. The earth's protective ozone layer gets compromised by CFCs, allowing dangerous ultraviolet (UV) rays to reach the earth's atmosphere [18]. Exposure to ultraviolet (UV) light can cause a variety of illnesses, including weak immune systems, eye diseases, and cancerous tumors on the skin. Approximately 98 million metric tons of greenhouse gas equivalents were released into the environment as a consequence of the incorrect handling of discarded cooling and freezing devices [19]. Air, water, and soil pollution are the consequences of e-waste landfilling and combustion. Because e-waste contains some hazardous and toxic substances that take a long time to break down, improper disposal of it degrades soil fertility [20]. Hazardous pollutants also contaminate groundwater. When e-waste is burned, harmful gases are released into the atmosphere [21].

E-waste Management Strategies

To deal with challenges at the national and international levels, e-waste management is currently the subject of substantial study. For the purpose of managing e-waste, multiple devices have been designed [22]. The recovery of rare and valuable metals as well as the separation of parts that could be recycled are subjects of research. This section highlights upcoming advances and provides an overview of the variety of approaches that have been used.

- **Life Cycle Assessment(LCA):** A method that is used to reduce e-waste problems and build sustainable devices is life cycle assessment [23]. To create eco-designed products including laser printers, personal computer systems, washers and dryers, cooling devices, and toys, life cycle assessment (LCA) is a formidable instrument for determining possible environmental effects [24]. Additionally, it is a methodical instrument for establishing a wide range of environmental impact categories, such as the development of land, eutrophication, acidification, and global warming [25]. Life Cycle Assessment (LCA) is a popular tool for handling electronic waste. It has been used for assessing perceived risk, economic factors, and environmental effects [26].
- **Material Flow Analysis (MFA):** MFA is a technique used for examining the path that material takes as it flows into disposal or recycling locations, as well as the temporal and spatial distribution of material stocks [27]. It combines the material's starting locations, routes, and intermediate and end points. Material flow analysis is used to create an effective e-waste management system [28]. In India, system analysis of the Au and Cu that come from the recycling of personal computers is done using MFA and economic evaluation. It came to light that recycler earned profits from of the high value and concentration of Au and Cu metals [29]. The results of the study show that when there is rapid economic growth and little data available, linking MFA and economic evaluation might be a valuable tool [30].
- **Multi Criteria Analysis (MCA):** MCA is an approach to decision-making geared toward resolving complicated multiple-factor issues with both qualitative and quantitative components [31]. It is intended to be used for making strategic decisions. MCA models have been used to provide optional e-waste management options for a variety of environmental issues, including e-waste management [32]. MCA is used to assess the trade-offs between financial gain and benefits to the environment [33]. MCA is a helpful tool when used in conjunction with other e-waste management techniques, as it has been suggested for social response to e-waste management.
- **Extended Producer Responsibility (EPR):** Based on the idea of polluter-pays, the environmental policy approach known as EPR holds producers accountable for returning products to them after they have been used. Maine's EPR program is only applicable to computer monitors and televisions [34]. Three parties are involved in this program's e-waste management: the government, the power companies, and the various stakeholders [35].

Conclusion

The electronic waste is an important concern on the local and worldwide level. E-waste issues first surfaced in industrialized nations and are currently widely present in other nations. E-waste is composed of up of a wide range of elements, some of which are harmful and can harm human health as well as pollute the environment. This paper reviewed several electronic waste management strategies that not only help remove harmful materials from the waste but also recover precious metals that could eventually lead to significant commercial possibilities in developing countries like India. Most electronic waste issues might eventually be resolved with the help of a number of methods, such as the LCA, MFA, MCA, and EPR method for managing electronic waste. Based on the present economic, social, professional, and ecological reality and demands in light of numerous effective techniques and approaches used in many nations, the study recommended an integrated e-waste management system. In order to adapt the ordinances, laws, and regulations pertaining to e-waste to better suit the Indian context, more investigation, evaluation, and research are needed. It is also necessary to figure out the most ecologically friendly methods of reuse and recycling, discarding of, and managing e-waste that contains different types of dangerous and poisonous components.

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5

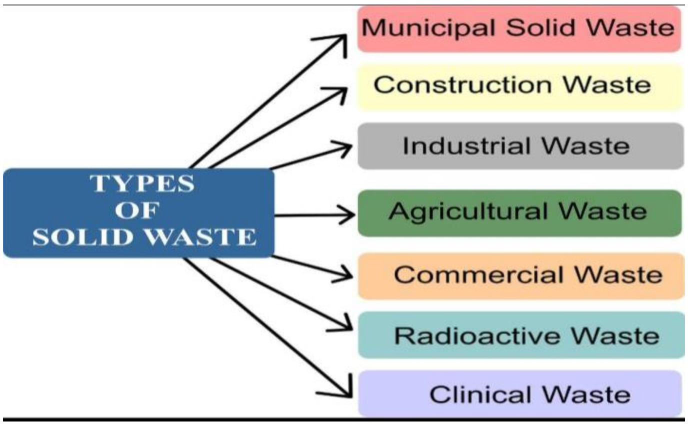
Review on Solid Waste and Solid Waste Management

Medha Babel[*]

Introduction

Solid waste material is defined as a discarded material which is generated by human activities in commercial, industrial and residential areas. Waste is also defined as any product which is useless to the producer [1]. The people want to dispose of the solid waste materials [2]. Solid waste materials are non-liquid and insoluble materials. These solid waste materials are responsible for water pollution, air pollution etc. Product packaging, paint cans, kitchen refuse, clothing, bottles are some examples of organic and inorganic solid waste materials. A maggot growth can be placed in cities and consumption centre due to the solid waste such as fruits, plant products and domestic waste [3] which are dumped in open air and has heat & moisture which are the reason of growth of maggots inside the waste material.[4]

The solid waste materials show adverse effects on human health and also affects the sustainability of environment and responsible for several diseases, infection, fever, typhoid etc. Waste material also overseeing for climate changes due to rising in temperature and contribution of greenhouse gases. These affects the people with cardiovascular problems and respiratory problems.[5]



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Types of Solid Waste

- **Municipal Solid Waste**

The composition of municipal solid waste materials includes food and garden waste, plastics, paper, glass, metals and textiles [6].

- **Construction Waste**

Construction solid wastes are collected from construction materials such as concrete, plastics, metals, wood, glass etc.

- **Industrial Waste**

Industrial solid waste comes from raw materials, fruit shells, palm fibre etc.

- **Agricultural Waste**

Crop residues, animal manure, rearing of livestock etc are the examples of agricultural solid waste. Agricultural solid waste is responsible for environmental hazard.[7]

- **Commercial Waste**

Commercial solid wastes are solid or semi solid which are produced by the commercial sector such as consumer electronics, batteries, paper, metal, plastics, food waste, glass, white goods.

- **Radioactive Waste**

Radioactive solid waste is produced from nuclear power plants.

- **Clinical Waste**

Clinical solid waste comes from research, diagnostic laboratories, blood contaminated materials, expired drugs, garbage from hospital etc.

Consequences of Solid Waste Materials on Environment

- **Water Pollution**

Disposal of solid waste material into surface water is superintend of water pollution. Due to mixing of municipal solid waste into water a contaminated leachate is produced which is dangerous for human health and environment.

- **Soil Pollution**

Solid waste materials, fertilizers, pesticides, plastic materials which do not compose easily and waste water which enters in the soil are detrimental for soil and liable for soil pollution.

- **Air Pollution**

Combustion of solid waste material containing organic substances and plastics emit various gases such as CO_2, CO, H_2S into the air which are dangerous for human health and environment.

Solid Waste Management

As mentioned above the solid waste materials are harmful for our environment so proper planning and control is required to prevent hazardous effect on environment and this is fulfilled by solid waste management. Solid waste management includes the recycling process, control of waste generation, collection, transport, disposal in a manner to avoid the adverse effects on human health and environment.Solid waste management (SWM) is an integral part of an environmental management system. A SWM system refers to a combination of various functional elements associated with the management of solid wastes.

The following elements are the constituents of solid waste management:

- Waste generation
- Waste storage
- Waste collection
- Transfer and transport
- Processing
- Recovery and recycling
- Waste disposal

Methods used for Waste Disposal in Solid Waste Management

- Composting techniques
- Anaerobic digestion for producing energy
- Incineration
- Sanitary landfilling [8]

Conclusion

This review article focuses on the sources of solid waste materials and consequences of solid waste materials on environment. Also, this review article signifies about the various elements of solid waste management. The main objective of this review is aware the people about controlling solid waste and harmful effects on environment.

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6

Integrative Approach to Solid Waste Management: A Brief Review

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Introduction

One of the most important concerns in the modern world is safeguarding human civilization from the corrosive influence of artificial wastes. Wastes are, in fact, the portion of raw materials left over after their primary use and are typically undesired [1]. Solid wastes are one type of waste material that is produced in our society by diverse human activities. Solid waste is now one of the major environmental problems facing the world. Village, agricultural, municipal, and hospital solid wastes are the main categories of solid wastes [2]. A significant portion of degradable and recyclable materials are found in village wastes (VWs). However, agricultural solid wastes (ASWs) have the potential to contaminate groundwater and render soil infertile. Strong economic growth, urbanization, population growth, and rising levels of communal life have all contributed to a major increase in the world's solid waste production. The exponential increase in the human population, along with the swift industrialization and urbanization, has resulted to a massive generation of trash [3]. The World Bank project projected that urban settlements will produce about 1.3 million tones of municipal solid waste (MSW) annually by the end of 2025, a doubling of that amount. Waste creation has increased globally as a result of rapid urbanization, population growth, and economic development [4]. The combination of rising energy and material consumption rates, rapid population development, and high living standards results in significant amounts of municipal solid waste output, which, if improperly disposed of or recycled, poses major environmental risks[5].Two new issues that are harmful to sustainability and environmental preservation are industrial

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development and urbanization. Solid waste management and disposal represent a global challenge. Due to their expanding populations, rising living standards, changing lifestyles, and increasing rate of trash generation—which raises the amount of land needed for waste disposal—developing countries are particularly affected by this problem [6].

The need for solid waste management arises when a civilization shifts from an agricultural one with a low population density and a wide distribution to an urban one with a dense population. The decentralized method of solid waste management (SWM) is mostly determined by each nation's economic standing [7].It involves a number of activities pertaining to the creation, preservation, gathering, transportation, processing, and disposal of solid wastes. Regardless of the location or nation, the first stage in every waste management strategy is monitoring the creation of waste. Because there are several interrelated processes involved in waste management, as well as highly changeable demographic and socioeconomic aspects affecting the overall systems, these processes include complicated operations and non-linear parameters [8]. Eco-friendly methods of mitigating the toxicological endpoints of these pollutants on environmental elements, animals, and plants have been described. A few more distinct remediation strategies, which have been reported for waste management, include microbial-mediated biodegradation, membrane bioreactors (MBRs), anaerobic ammonium oxidation, advanced oxidation processes (AOPs), phytoremediation [9]. Solid waste management and disposal is a global challenge. Around the world, landfilling is a common process for disposing of non-recyclable trash; however, in certain poor nations, the waste is dumped into pits or mounds rather than being covered with soil. Additionally, landfills can serve as designated locations for the disposal of municipal solid waste where recyclables can be sorted and garbage can be processed [10].

Types of Solid Waste

- **Agriculture Solid Waste**

Waste from farms, hatcheries, and woods is primarily referred to as agriculture waste. Biomass and reusable biodegradable materials are particularly enriched in these wastes. Most agricultural operations result in the production of solid waste. But it goes beyond production to include other farming and food chain-related activities [11].Significant amounts of agricultural solid waste can be produced at every stage and phase of the food chain. Agriculture waste is a major source of harmful substances that contaminate surface and groundwater. This waste is the result of over fertilizing fields when surface water eutrophication has produced excess nitrogen (N) and phosphorus (P) in the fertilizer [12]. The ecological system of an aquatic body is allegedly harmed by eutrophication consequences. As a result, it lowers oxygen levels and promotes the growth of aquatic weed, which can kill off wildlife and plants.

Medical solid waste on farms is produced when medications, pesticides, or vaccines are administered to animals. One immediately thinks of wood processing and cutting as a source of solid agricultural waste [13]. A certain amount of agricultural solid waste is produced during the manufacturing of paper from agricultural goods. Due to the production of heavy metals, herbicides, and pathogens in the soil, poultry waste is also contaminating surface and groundwater. Most notably, nitric nitrogen (NO3–N) found in poultry manure is the cause of human infants' "blue baby" illness [14].

- **Municipal Solid Waste**

The origin of municipal solid waste is the solid garbage that is gathered from homes, workplaces, small-scale institutions, and commercial businesses by the municipality. Although it is composed of both biodegradable and non-biodegradable fractions from organic and inorganic components, respectively, municipal solid waste differs greatly in composition and classification between different towns worldwide [15]. The usual waste materials that are included in municipal solid waste are kitchen waste, yard waste, paper and cardboard, plastic and rubber, metal, glass, electronic waste, inert materials, and other random trash. Due to rapid urbanization and the growing global population, there has been a noticeable increase in the production of municipal solid garbage in recent years [16]. A necessary component of daily living is the generation of solid trash from households, which accounts for the majority of municipal solid garbage. Due to rapid economic expansion and rising living standards over the past few decades, there has been a huge increase in the generation of household solid trash. Developed countries have increasing fractions of plastic and paper garbage with low moisture content and high heating value in their municipal solid waste[17]. The movement that results in a significant quantity of MSW generation is also influenced by the population increase and continuing industrialization. In addition, it contains solid particles, grit debris, microbiological pathogenic organisms that cause disease, and a number of dangerous substances in amounts that exceed the specified allowable limits. Direct municipal wastewater discharge into bodies of water and the surrounding soil can lead to serious aesthetic issues with discoloration and smell [18]. Through waste-to-energy or energy-from-waste conversion and other valorization procedures, municipal solid waste is a renewable and cost-effective resource with significant potential for the recovery of energy and precious resources. The pace at which MSW is generated is rising quickly in a number of nations that are experiencing rapid development and incremental improvements in their GDP. Only in India is the rate of MSW creation eight times higher now than it was in 1947 [19]. Just 25% of the municipal solid waste collected worldwide is directed towards waste management techniques like composting, anaerobic digestion, and recycling. Since different nations have different waste recycling patterns and practices, it is crucial to ascertain the most efficient method for the treatment or disposal of municipal solid waste worldwide [20].

- **Industrial Solid Waste**

Waste from factories, mills, and mines is produced by industrial activities. Even now, it frequently makes up a sizable amount of solid trash [21]. Various chemical, solid, liquid, toxic, and flammable wastes, pesticides, hazardous metals, and organic hydrocarbon wastes that, depending on their complex nature, can either degrade or remain non-degradable are all included in the two main categories of industrial waste: biodegradable and non-biodegradable [22].

- **E-Waste**

E-waste, also known as waste electrical and electronic equipment, or WEEE, is the term used to describe complete electrical or electronic items that are broken, surplus, outdated, or carelessly destroyed at the end of their useful lives [23]. A wide range of items, mostly composed of heavy metals, plastic, toxic pollutants, and other elements, make up e-waste. Over the past ten years, e-waste has emerged as one of the waste sources with the fastest historical growth worldwide [24].

Solid Waste Management

Solid garbage generation is rising daily due to population growth worldwide. Only in India does it range from 0.2 to 0.6 kg/capita in urban areas, producing 42 million tons of total solid waste annually; by 2047, these numbers will surpass 260 million tones. In waste treatment plants, operational efficiency has always been crucial [25]. Process design, treatment efficiency, and facility running time all have a major impact on how efficient a treatment facility operates. Significant progress has been made in the last few years in the creation of new technologies, but there are still numerous obstacles to overcome. Small variations in any of the operations at any point may complicate the success rates; management should be initiated from the beginning of collecting until the completion of disposal in every stage to ensure noticeable management [26]. Some techniques are briefly discussed -

- **Landfilling**

The process of organizing the systematic disposal of both biodegradable and non-biodegradable wastes in a designated landfill, which is situated outside of a municipality's suburban districts, is known as landfilling [27]. Although it ranks lowest in terms of waste management quality, landfilling is the most universal and effective method of disposing of trash. Lands that are the primary source of greenhouse gases are used for the disposal of all forms of inert waste, leftover and residual waste treatment material, organic garbage, and mixed waste [28]. The content of landfill leachates, which are mostly biodegradable but can also contain some refractory materials, metals, ammonia, nitrogen, and humic compounds, as well as chlorinated salts, depends on how old the landfill is. Open dump dumps, semi-controlled landfills, and sanitary landfills are the different types of landfills [29]. Open dump dumps are prevalent in developing nations worldwide, when rubbish from municipal solid waste is haphazardly disposed of in open, low-lying locations [30]. Municipal solid waste garbage is sorted, shred, and compacted on-site before being disposed of in semi-controlled landfills, which are run landfills situated in approved dumpsites. To stop annoyances like the growth of scavenger birds, animals, vermin, and microbes, the disposed-of thrash piles are crushed, levelled, and covered with a layer of topsoil every day using bulldozers or crawlers [31]. Modern landfilling technology guarantees the best possible use of solid wastes with the least amount of contamination risk possible when using a sanitary landfill. This method appropriately follows accepted USEPA standard procedure [32].

- **Biochemical Degradation**

Recently, the cost of this technology for the stabilization and disinfection of waste, such as animal slurries, industrial sludge, and agriculture residue, has decreased. The primary aim of this procedure is to produce biogas, which comprises 50–60% methane, by means of composting organic waste [33]. Using anaerobic microbes to effectively break down and utilize organic waste and produce clean energy gas, anaerobic digestion is an environmentally favorable method. It efficiently addresses the issue of disposing of organic waste in addition to providing energy for today's civilization [34]. Microbial biomass, such as fungi, bacteria, yeasts, and algal biomass, as well as non-living biomass, such as prawns, krill, squid, crab shells, etc., are potential microorganisms used to treat diluted heavy metals and for the biodegradation of dyes in wastewater. The benefit of this treatment approach is that methane gas, which is produced during the anaerobic digestion process, can be used as a renewable energy source [35].

- **Pyrolysis**

Pyrolysis is the process of heating solid organic waste in an anaerobic environment to cause chemical breakdown that eventually yields liquid bio-oil, chemical gas, and bio char. The conditions of the reaction determine the proportion of these chemicals in the finished product [36]. Depending on how long the burning process takes, there are three different forms of pyrolysis: slow, fast, and flash pyrolysis. The generation of fuel gases, the ability to use pyrolysis oil as a diesel additive blend, the modular design of the pyrolysis units, and the reduction of air pollution are all benefits of pyrolysis [37]. The main drawbacks of pyrolysis include low net energy output with high moisture content, production of toxic gases such as hydrogen cyanides and polyacrylonitriles, high oil viscosity (i.e., low transportability), and the expensive requirement for waste pre-treatment in order to produce pyrolysis oil from solid waste [38]. Char is mostly composed of carbon and inflammable elements, with syngas such as hydrogen, carbon monoxide, and methane making up a large portion of the mixture. These gases can also be condensed for the manufacturing of wax and tar and used to generate fuel oil [39].

- **Incineration**

The process of burning waste materials at high temperatures and oxygen pressures to produce high-temperature combustion fuel gas and a stable solid residue is known as incineration. Heat is then released during this process [40]. Both the elimination of hazardous materials and the recovery of energy result from this process. This technique has the advantages of being largely odorless, noiseless, and highly energy efficient [41]. Particulate creation, emissions of SOx and NOx, dioxin production, high skill and handling requirements, and high cost are some of the drawbacks of this method [42].

- **Adsorption**

Adsorption is a physical treatment method that effectively removes and recycles organic, metallic, and chlorinated contaminants [43]. Through a procedure known as phase transfer, contaminated materials are typically taken out of the fluid phase—either gaseous or liquid—and placed on a solid surface, where they are either chemically or physically bonded. Heavy metals and dyes in the aqueous phase have been effectively removed by adsorption [44]. The adsorption process has the following benefits: it requires no fertilizers, it is highly efficient in detoxifying much diluted effluents, it minimizes the amount of chemical and/or biological sludge that needs to be disposed of, and it has minimal running costs. Furthermore, no toxic compounds are formed as a result of adsorption [45].

Conclusion

Rapid economic growth and globalization have resulted in a large amount of solid waste being produced, which has drawn attention from all over the world due to possible resource waste and environmental effects, such as illicit industrial waste dumping and cross-border movement, unofficial e-waste recycling, food loss, greenhouse gas emissions, and resource consumption from excess packaging. Whether on purpose or accidentally, human civilization is about to produce an enormous amount of solid waste, which could have detrimental effects on health. Even more beneficial will be living a more eco-friendly lifestyle, adopting a minimalist mindset, and abiding by waste management regulations**.** The concept of waste management encompasses more than just treating and disposing of waste; it involves a whole system that includes minimizing waste production, gathering, sorting, and safely transporting waste to the appropriate recycling center. Evaluating the long-term economic viability of solid waste management pathways is crucial, as it allows managers to handle the growing volume of solid waste with more efficiency and adaptability.

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7

Study on Conductometric Titrations

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Introduction

A technique where in the conductometer, which measures the changes in conductance of the solution created by the ions in the solution, is used to determine the moment at which the reaction is finished. The basis of a conductometer's operation is Ohm's law. To determine an acid's strength, we place the acid in a beaker and submerge the conductometer's electrode into the solution. This gauges the acid's conductivity. Now that we are titrating this acid solution against a known-molarity base, the conductance begins to decrease. This results from the acid's H+ ions binding to the base's OH- until a minimum conductance is obtained. As we proceed, the conductance begins to rise once more. This is now due to the free ions of Base present in solution. The employment of an ionic exchange resin as an electrolyte for a space application by General Electric in 1959 brought polymer electrolyte membrane fuel cells to the attention of the general public [1]. A year later, the same company created the idea for a new electrolyzer that employed a solid polymer electrolyte rather than a liquid alkaline electrolyte in an effort to overcome the drawbacks of alkaline water electrolyzers [2]. The point at which this transition occurs is called Equivalence point. At Equivalence point we measure the volume of base used to neutralize the acid ions completely in the solution. Putting these values in formula we can get the strength of acid.

In order to reduce the influence of errors in the conductometric titration to a minimum, the angle between the two branches of the titration curve should be as small as possible. If the angle is very obtuse, a small error in the conductance data can cause a large deviation. The following approximate rules will be found useful.

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- The outcome will be more accurate the smaller the conductivity of the ion that replaces the reactive ion. Titrating a silver salt with lithium chloride is therefore preferred over HCl. Since acetates have low conductivity, cations should typically be titrated with lithium salts and anions with acetates.
- The angle of the titration curve is more acute the larger the conductivity of the anion of the reagent that reacts with the cation to be tested, or vice versa. Since the conductivity increases steadily from the beginning, titrating a mildly ionized salt does not yield satisfactory results. Hence, the salt present in the cell should be virtually completely dissociated; for a similar reason; the added reagent should also be as strong electrolyte.
- Non-linear titration curves occur when the volume of the solution increases continuously during a titration, unless the conductance is adjusted for this impact. V is the initial volume of solution, and V´ is the total volume of the reagent supplied. The measured conductance can be corrected by multiplying it by either total volume (V+V´) or by the factor (V+ V´)/V. The correction relies on the assumption that the conductivity is a linear function of dilution, which is only roughly right.
- The reagent for the conductometric titration is typically several times (at least 10–20 times) more concentrated than the solution being titrated in order to minimize V. The volumetric measurement can then be performed using a micro burette.

Fuel cells with proton exchange membranes have grown in significance for uses requiring short response times to load variations and quick startup [3]. The essential part of those kinds of devices are proton exchange membranes, and their specifications must include low electronic conductivity, high proton conductivity, good chemical and thermal stability, low permeability to fuel and contaminants, low electro-osmotic drag coefficient, good mechanical qualities, and low cost [4].

Conductometric Titrations

If there is a discernible difference in conductance between the reagent of the reaction product and the original solution, the conductance method can be utilized to monitor the titration's progress. The equivalency point can be found with relative values alone; therefore knowledge of the cell constants is not required. An ion's conductance is proportionate to its concentration (at constant temperature), but due to the dilution effect of adding water at the same time as the reagent, a given solution's conductance will typically not change linearly with the addition of reagent. Deviations from linearity can also result from the partially soluble product of a precipitated product or from the hydrolysis of reactants or products. It is simple to estimate the titration curve's shape. The concentration of each ion at any point in the titration is calculated by the usual methods based on stoichometry, equilibria, and dilution.

An analytical method known as conductometric titration uses the concept of mobility difference, whereby ions with mobility are substituted for ions with a different mobility. When compared to acid-base or potentiometric titrations, this method has advantages when it comes to studying specific systems. These systems are those that produce hydrolysis products at the same spot or products with a significant degree of solubility. Aside from that, the conductometric titration remains accurate in both concentrated and relatively diluted solutions. This method can be used to investigate both colored and colorless liquids. Since they have no effect on the system being studied (the reaction), the measurement electrodes are the only component that is not a part of the solution [5].

Principle

The foundation of the conductometric titration concept is the observation that, as one ion is substituted for another throughout the titration process; the ionic conductivities of the two ions are inevitably different, causing the conductivity of the solution to fluctuate during the titration process. By graphing the change in conductance as a function of the volume of titrant added, the equivalency point can be found visually. The following are the main ideas:

- The ability to conduct Adjust: -The capacity of a solution to convey an electric current is known as conductivity. Conductivity changes as a result of the reaction between the titrant and analyte in a conductometric titration.
- Endpoint Detection: - The analyte and titrant reaction having reached its conclusion is the titration's endpoint. Conductivity has changed significantly at this time.
- Formation of Ionic Species: - The presence of ions largely affects a solution's conductivity. The titration process modifies the conductivity of the solution by causing ions to form or be consumed as a result of the chemical reaction.
- Titration Curve: - A titration curve is created by graphing the conductivity against the volume of titrant applied. The exact volume of titrant required for full reaction is indicated by the curve's inflection point, which matches the equivalency point.
- Sensitivity and Selectivity: - Conductometric titrations are sensitive to a wide range of reactions involving ions. The method is selective in detecting specific ions based on their conductivity changes.
- Titration Types: -Conductometric titrations can be applied to various types of reactions, including acid-base, precipitation, and complexation reactions. The choice of titration depends on the nature of the chemical reaction being studied.

Overall, the principle of conductometric titrations relies on monitoring changes in electrical conductivity to determine the endpoint of a titration accurately, providing a valuable tool for quantitative analysis in diverse fields of chemistry.

On the other hand, the indicator may cause contamination or interact with the system during the acid-base titration. Because of the potential impact of indicators' broad pH range on the determination error value, using them comes with additional drawbacks [6]. The system under study does not contain high quantities of unusual electrolytes, which could interfere with the reaction and significantly lower the precision of the results [7].

This is the drawback that the conductometric titration brings. Because it took longer to reach system equilibrium at lower concentrations, it was necessary to employ that concentration or higher. The duration of a full titration experiment was set at 36 hours [8].

The key components that determine the conductivity of the solution.

- **Ion Size**

The size of the ions is inversely correlated with the conductivity of the solution. Because the ions' mobility will decrease as their size increases, the conductivity of the solution will decrease if the ions' size increases.

- **Temperature**

The mobility of the ions in the solution will increase as the temperature rises. Thus, the conductivity of a solution is directly influenced by temperature. For example, conductivity will rise with temperature and vice versa.

- **Reactant Concentration**

The analyte and titrant concentrations have a direct impact on how much the conductivity changes. Higher concentrations often lead to more pronounced conductivity changes, improving the precision of the titration.

- **Nature of the Reaction**

The conductometric titration curve's form and the ease of endpoint detection are influenced by the type of chemical reaction (acid-base, redox, complexation, or precipitation) that takes place during the titration.

- **Electrolyte Strength**

The strength of the electrolytes created during the titration affects the conductivity of the solution. Conductivity is more influenced by strong electrolytes than by weak electrolytes.

- **Electrode Characteristics**

The sensitivity and accuracy of conductometric titrations might be impacted by the kind and state of the electrodes used in the measurement. It's crucial to maintain and calibrate electrodes properly.

- **Purity of Reagents and Solvents**

Base conductivity can be impacted by impurities that bring extra ions into reagents or solvents. Accurate findings depend on highpurity chemicals.

- **Titration Pace**

The form of the titration curve and the sharpness of the endpoint can be affected by the pace at which titrant is introduced. Although it could increase accuracy, slow adding may cause unintended consequences.

- **Effects of the Solvent**

The solution's conductivity may be impacted by the solvent selected. Although aqueous solutions are usually used for conductometric titrations, non-aqueous solvents can also be used with some adjustments.

- **Titration Conditions**

A number of factors, including pH and ionic strength, can influence how ions behave in solution, which in turn can affect conductivity and the titration curve.

- **Instrument Calibration**

Accurate and dependable findings depend on the conductometric titration apparatus, comprising electrodes and measuring instruments, being properly calibrated.

- **Sample Contamination**

External contamination has the potential to add extra ions to the sample, which could alter the baseline conductivity and cause titration errors.

Advantages

- **High Sensitivity:** Conductometric titrations have a high degree of sensitivity, making it possible to identify even minute changes in conductivity. For an accurate determination of the endpoint, this sensitivity is essential.
- **Wide Applicability:** This technique is flexible enough to be used in many different areas of chemistry and can be applied to a range of titrations, such as acid-base, redox, complexometric, and precipitation processes.
- **Real-Time Monitoring:** The titration process can be observed in real-time using conductometric titrations. Rapid changes in conductivity make it possible to identify the endpoint right away.
- **No External Indicators Required:** Conductometric titrations frequently don't call for external indicators, in contrast to certain
- **Other titration techniques.** An inherent indicator is provided by the abrupt drop in conductivity at the equivalency point.

- **Quantitative Analysis:** Accurately determining the concentration of analytes in a sample is made possible by the suitability of conductometric titrations for quantitative analysis.
- **Basic apparatus:** Conductometric titrations use very simple apparatus, which makes the technique useful for both normal laboratory work and teaching.
- **Non-Destructive:** Conductometric titrations are frequently non- destructive, enabling the recovery of the sample under analysis following the completion of the titration.
- **Adaptability to Non-Aqueous Systems:** Conductometric titrations can be extended to organic reactions and materials with low water solubility by adapting them for non-aqueous solvents.
- **Cost-Effective:** Compared to certain other titration techniques, conductometric titrations are more affordable due to the ease of use of the apparatus and the absence of the requirement for external indicators.[9]
- **Educational Value:** Conductometric titrations are useful in classrooms because they give students practical experience with titration methods and analytical chemistry concepts.
- **Possibility of Automation:** Technological developments have made it possible to automate conductometric titrations, increasing accuracy and lowering the possibility of human error.

For a variety of applications, conductometric titration is a preferred method in many analytical laboratories due to itssensitivity, adaptability, and ease of use.

Conclusion

To sum up, conductometric titrations are an extremely useful and adaptable analytical method with a wide range of applications in various areas of chemistry. Numerous benefits flow from the method's emphasis on measuring changes in electrical conductivity during chemical reactions, including high sensitivity, adaptability to different types of titrations, and the ability to observe changes in real time. Conductometric titrations are still essential for research, environmental monitoring, and quality control in the food and pharmaceutical industries, even as technology develops. The method's versatility in handling aqueous and non-aqueous systems, together with its capacity to offer non-destructive analysis, further augments its usefulness in tackling intricate analytical problems. Fundamentally, conductometric titrations continue to be an essential component of analytical chemists' arsenal because they provide a strong and user-friendly way to comprehend and measure chemical reactions with wide-ranging ramifications for both scientific study and industrial applications.

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8

Different Method to Measure Solid Waste and Factors affecting their Generation Rate: A Review

Prerana Gaur*
Dr. Nidhi Gupta**

Introduction

There is a rising demand for goods as a result of the population's rapid growth. Production, consumption, and rejection from a variety of industries, including commercial, industrial, institutional, and agricultural, thereby rise as well. Solid waste is the term used to describe this huge amount of rubbish generated and rejected.

A significant amount of this solid waste is non-biodegradable, necessitating recycling because it depletes natural resources and jeopardizes effective and sustainable development. Solid waste management is a step in the recycling process that includes managing waste generation, storage, collection, transportation, and appropriate disposal. The solid waste measuring approaches covered in this review paper include the weight-based method, the volume-based method, composition analysis, sampling strategies, trash creation rates, and technological tools.[1]

Weight based Method

A weight-based approach to measuring solid waste entails separating the debris by hand and determining its quantity and composition. An overview of a common strategy is provided below:

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- **Sampling Waste:** Random Sampling: Choose representative samples from various points in the waste generation area. Sampling that is stratified: Sort garbage into groups (called strata) according to attributes such as origin or kind. To achieve a thorough analysis, sample each stratum.
- Waste was manually sampled and categorized, with recyclables, organics, and non- recyclables being separated out. Automated Sorting: Classify garbage according to predetermined criteria by using automated sorting technology, such as sensors and conveyor belt.[2]
- **Weighing:** Measure the weight distribution of recyclables, organics, and non-recyclables by weighing each group independently. Total garbage: To determine the overall amount of garbage generated, weigh each sample of rubbish.
- **Composition Analysis:** Visual Inspection: Use visual analysis to determine common components and objects in the waste's composition.[3] Laboratory Analysis: To ascertain the percentage composition of various materials (such as plastics, paper, and glass), do a thorough laboratory analysis on representative samples.
- **Extending Data:** The process of scaling involves estimating the overall waste produced for an area or population by extrapolating the results from the waste sample. Statistical Techniques: To account for variability and offer confidence intervals for the estimates, use statistical techniques.
- **Consistent Monitoring:** Periodic Surveys: Measure trash periodically to record seasonal variations and shifts in waste composition over time. Continuous Monitoring: To track trash creation trends in real-time, if at all practicable, implement continuous monitoring systems.
- **Integration of Data:** GIS Mapping: For geographical analysis and planning, combine waste data with Geographic Information System (GIS) mapping. Database Management: Keep an extensive database up to date for effective record-keeping and future use.

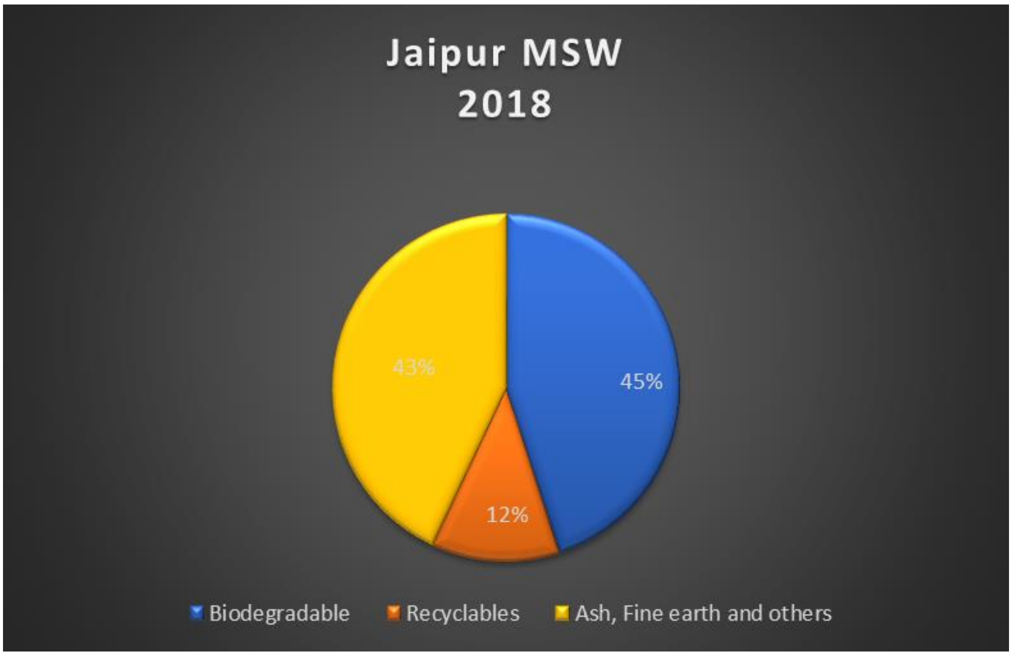
Volume based Method

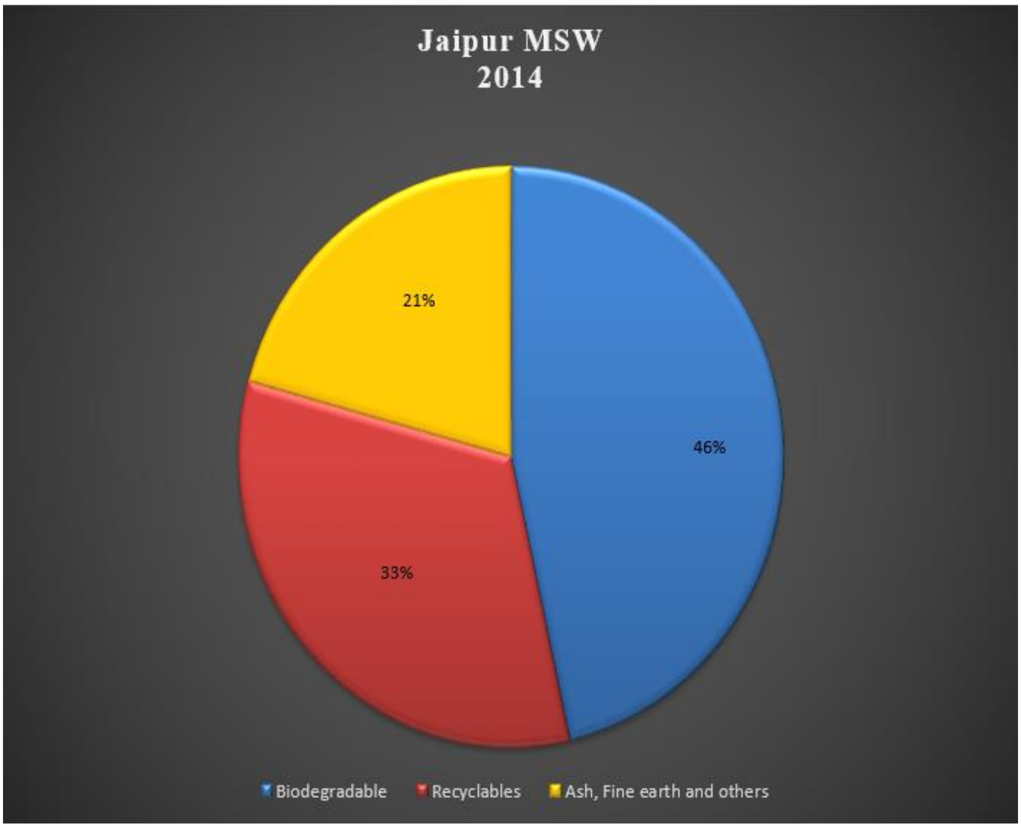
Solid waste can be measured using a volume-based approach, which measures the garbage's actual volume as opposed to its weight. Below is a summary of the steps in this approach:

- **Measurement of Container Volume:** Container Types: Determine and quantify the quantities of different types of garbage containers that are collected, such as bags, dumpsters, and bins. Standardization: To maintain consistency, make sure measurements are standardized.[4]

- **Evaluation of Container Fill Level:** Visual Inspection: To determine the amount of waste produced, visually evaluate the fill levels of waste containers on a regular basis. Sensor Technology: Use sensor technologies to automatically measure fill levels, such as ultrasonic sensors.
- **Compressive Strength of Waste:** Compaction Ratio: If garbage is compacted prior to disposal, take this into account. This ratio aids in calculating the volume that existed prior to compaction. Monitoring the Compactor: In order to ensure precise volume estimates, keep an eye on the compaction cycles and ratios while using waste compactors.
- **Spatial analysis and GIS mapping:** Mapping Container Locations: To map the locations and capacities of garbage containers, use Geographic Information System (GIS) mapping. Spatial Analysis: Use spatial patterns analysis to find areas with different rates of garbage generation and to optimize waste collection routes.
- **Engagement with the Community:** Public Reporting: To offer information on garbage volume, encourage locals or companies to record container fill levels or take part in citizen science projects. Smart Bins: Use sensors to communicate fill level data for real- time monitoring by implementing smart bins.
- **Consistent Reporting and Monitoring:** Scheduled Inspections: Measure and check frequently to monitor variations in waste volume over time. Data Reporting: To record volume measurements and trends, keep an organized reporting system.
- **Integration and Analysis of Data:** Data Compilation: Combine a large amount of data with historical records to create a thorough database. Analytical Tools: Make use of analytical tools to spot trends, connections, and possible waste reduction opportunities.
- **Education and Public Awareness:** Feedback Loop: Create a feedback loop by supporting waste reduction activities, raising awareness, and providing the community with volume statistics. Educational Campaigns: Run educational initiatives to encourage ethical trash disposal methods. Volume-based approaches provide useful information on the patterns in waste generation, especially in places where weight-based measures could be difficult. Planning infrastructure, involving the community in sustainable waste management practices, and streamlining waste collection routes are all made possible with this strategy.

Factors Affecting SWM System





- **Population:** Growth in Population: The increased consumption of goods and services that comes with a growing population frequently results in increasing waste generation. Urban Migration: Dense populations growing quickly in cities can result in concentrated trash production, posing a challenge to the infrastructure supporting garbage management.
- **Urbanization:** Consumption Patterns: Consumption patterns in urban areas are altered, with a preference for packaged and convenience goods, which leads to an increase in non- biodegradable trash. Demands on Infrastructure: To handle the increased concentration of waste generators, urbanization necessitates a strong infrastructure for waste management.[5]
- **Economic Factors:** Consumption and Affluence: Higher consumption and affluence can result in more trash being produced, especially in the form of packaging and electronic waste. Industrialization: When economies grow, industries tend to expand as well, bringing with them industrial waste that needs to be managed by specialists.
- **Cultural and Social Factors:** Lifestyle Changes: Changing social norms and cultural shifts have an impact on lifestyle decisions, which in turn has an impact on trash generation. For example, a culture that is more disposable is producing more solid trash. Attitudes Toward Recycling: The success of waste management programs is influenced by cultural attitudes on recycling and trash disposal methods. These elements frequently interact, each having a distinct effect on waste formation. For instance, higher levels of economic status and dense population in metropolitan areas may result in increasing production of electronic trash from increased technology use.[6] Similarly, a rise in non-biodegradable garbage can be caused by cultural norms that value convenience and single-use goods. It is essential to comprehend these interactions in order to create waste management plans that work. It entails taking into account the waste stream's characteristics and content in addition to its volume. In order to reduce the environmental impact of solid waste generation, sustainable solutions necessitate a comprehensive approach that incorporates social, cultural, economic, and urban planning factors.
- **Technological Variables:** Solid waste generation patterns are significantly shaped by technological elements. The following are some significant ways that technology affects this aspect:
    - **Product Design and Innovation:** Packaging Materials: New materials may be developed as a result of advancements in packaging technology, which may have an impact on the makeup of solid waste. For example, longer-lasting garbage is a result of packaging using more non-biodegradable plastics.

- **Production Procedures:** Efficiency and Waste Minimization: As manufacturing processes become more technologically advanced, production can become more efficient and waste produced during manufacturing can be minimized. Green and lean manufacturing techniques seek to reduce waste production.
- **Generation of E-Waste:** Obsolescence and Upgrades: As electronics technology develops quickly, products become outdated and require frequent upgrades. This leads to the disposal of outmoded gadgets, which creates a significant amount of electronic garbage, or e-waste
- **Technologies for Waste Treatment:** Waste-to-Energy: The quantity of waste dumped in landfills may decrease as a result of improvements in waste treatment technology like waste-to-energy conversion. Resources are recovered and energy is produced with the help of efficient waste conversion technology.5. Electronic commerce and digitization: Packaging and Delivery: The growth of digital services and e-commerce may have an impact on the production of solid waste by requiring more packing materials and effective delivery logistics.
- **Consumer Adoption of Technology and Behaviour:** Disposable Culture: The widespread use of technology might encourage a disposable culture in which things are thrown away with ease, which has an effect on the production of solid waste. This also applies to throwaway devices and electronics.
- **Technologies for Waste Management:** Sorting and Recycling: More efficient resource recovery is achieved through technological advancements in garbage sorting and recycling procedures. Recycling capabilities are improved by automation and intelligent technologies.
- **Astute Packaging:** RFID and Smart Labels: While smart packaging technologies like RFID and smart labels can increase the effectiveness of the supply chain, they also have the potential to introduce new elements that alter the composition of waste. It is vital to comprehend the intricate correlation between the development of technology and the production of solid waste in order to execute sustainable waste management strategies. In order to reconcile innovation with environmental responsibility, waste reduction methods must be adopted in tandem with the issues raised by new materials and consumption trends.

Conclusion

In conclusion, solid waste management done right is essential to the sustainability of the environment. We can lessen the effect that garbage has on our ecosystems by reducing, reusing, and recycling. Furthermore, appropriate disposal techniques—such as waste-to-energy technology and sanitary landfills—are essential for reducing pollution and fostering a healthier, cleaner environment. Adopting innovative solutions and sustainable techniques for solid waste management is our joint responsibility.

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