Treatment and Reutilization of Medical Waste

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1.introduction.

Pharmaceutical waste actually consists of several different waste streams that can damage the consistency and integrity of chemicals, including medications. Many processes in healthcare institutions might produce pharmaceutical waste. This covers IV treatment, routine dispensing, breakage, partially used ampoules, needles, IV drips, outdated unused dispensing, idle unit dosages, individual medications, and outdated medications. Including, but not limited to, the following, there are numerous choices for waste treatment and management, including diversion, minimization, reuse, energy recovery, and disposal.

Overview of Biomedical Waste:

Biomedical waste generally refers to solid or liquid wastes resulting from the diagnosis, treatment, or vaccination of humans or animals in related research or in the manufacture or testing of biological materials. Considered according to the world health organization(WHO), about 85% of hospital waste is actually non-toxic, about 10% is infections, and the remaining 5% is non-infections, but contains chemicals such as methyl chloride and formaldehyde. Contains dangerous chemicals. The main concern for hospital waste here is communicable diseases such as hepatitis B and hepatitis C viruses. In this situation, syringes and needles have the highest potential health risks.

Currently, hospital waste is not managed and is simply 'disposed'. When hospital waste is disposed of, it can be very dangerous as it mixes with urban solid waste and ends up in uncontrolled or illegal landfills such as neighbouring residential areas end slums. This can lead to threats to human health from various diseases such as AIDS, hepatitis, plague, cholera, etc. waste from health facilities carries more risk of infection and injury than any other waste higher.

In China, pharmaceutical technology can be classified by manufacturing method. the fermenting approach is the most well liked.in order to ferment, filter, and extract organic raw materials like antibiotics, vitamins, and amino acids, microbes must be active. The next step in the process is chemical chemist, which is a multi-step chemical synthesis employing organic or inorganic substances. There is yet another technique, known as herbal medicine, that is derived directly from plants and animals. The pharmaceutical business has grown quickly in recent years and now plays a significant role in China's national economy. 3.034 million tonnes of original compounds were produced in 2014, a 15.2% increase over the same period in 2013. China's pharmaceutical industry has the following characteristics. B. various small businesses and products, scattered overall deployments. By the end of 2014, the number of Chinese pharmaceutical companies reaches 7108, an increase of 8.9% over 2013. Of these, only 1,609 are large or medium-sized companies. However, with the developments of the pharmaceutical industry, environmental pollution is becoming more and more serious.

In Taiwan, Due to the significant threats to both human and environmental health, managing medical waste is an important issue. The analysis of recent trends in medical waste generation and treatment, as well as discussions of how the coronavirus disease of 2019(COVID-19) may affect its production in the firsthalf of 2020, were the main goals of this paper. The reported quantities were shown to have slightly grown from 35,747 metric tonnes in 2016 to 40,407 Mt in 2019, indicating an average increase of 4.17%. the hospital services were commensurate with this rate of growth. According to the given codes, roughly 89% of the reported quantities were classed as C-type garbage(infectious waste), which showed a 4.14% increase in annual growth over the same time period. Also, the majority of the medical waste treatment in 2019 depended on contracted treatment(80.18%), and self-treatment(1.29%).in addition, compared to the statistics from the years 2016-2019, COVID-19 had less of an effect on Taiwan's production of medical waste in the first half of 2020.it was stated that throughout this time, a consistent trend was seen in Taiwan's daily confirmed COVID-19 cases. It stands to reason that the rise in the production of medical waste from the medical services should more than make up for the decrease in hospital medical services during the COVID-19 outbreak. In an effort to guarantee the COVID-19 virus is destroyed completely and safely, all the waste generated from the healthcare facilities should be treated in the incineration plants.

The Central Pollution Control Board (CPCB) compiles country-wide annual data of based on the annual reports given by the relevant state pollution control boards/pollution control committees(SPCBs/ PCCs), bio-medical waste (BMW) creation, collection, and treatment. Around 656 days(TPD) of BMW was created in the year 2020, out of which 590 TPD was collected and treated by the common Bio-medical waste treatment facility(CBWTFs) (CBWTFs). Additionally, between May 2020 and February 2022, about 84.61 TPD of COVID-19 incremental BMW was produced in the nation by healthcare facilities, quarantine centres, sample collection centres, laboratories, and home isolation centres that were involved in the treatment, diagnosis, and quarantine of COVID-19 infected or suspected patients.

Water is an important raw material in the manufacture of pharmaceuticals and chemical products. Drinking water, process water , utility supply water, water recycling, wastewater, by-product treatment water, odour treatment water, desalination water, and irrigation water are some of the numerous categories of water that need to be handled as part of water management. Pharmaceutical fluids, which are frequently utilised as raw materials, components, and solvents in the processing, formulation, and production of pharmaceuticals, drug compounds and intermediates, compendial entries and analytical reagents, are the only topic covered in this review. Controlling the quality of process water is crucial in the production of pharmaceuticals and is also a legal necessity for sterilising contains or medical equipment in other healthcare settings, such as water for injection. Process effluents therefore include all water that comes into contact with raw material, products, intermediates, by-products or wastes treated in various unit operations or processes during manufacturing or processing.

In fact, the effluents from pharmaceutical units differ in content and concentration, and therefore have small volumes and produce different products from the same set of reactors and separators, so no unique treatment has been attempted. water reuse provides savings by reducing waste disposal costs and water supply requirements, offsetting operational costs associated with the waste reuse process.

After the manufacture's packaging is opened, some people think the unused or partially used product is just wasteful pharmaceutical material. Ampoules, vials, and bottles are a few examples. Another is unused or partially used containers. Unused or partially used medicine in bags or tubes. Medicines that have been discontinued and should not be used again if the patient vomits or drops them. This category also includes drugs that have been thrown away. Pharmaceutical waste includes discontinued medications that patients take home and lose, and it must be disposed of in accordance with EPA, state, and drug regulations.

An exception is solutions that do not contain drug additives. These can be introduced into sewage systems. Disposal of devices used to administer non-hazardous drug such as B. inhalers that use propellants are another consideration. In addition to RCRA requirements, some states have specific regulations regarding devices and propellants used to administer drugs for example, in Nebraska, hospitals must either separate inhalers from the normal waste stream or pierce the container and flush in three times before disposing of it in the harmless waste stream.

Rivers, aquifers and aquifers can be supplied with pharmaceutical chemicals, active ingredients and pharmaceuticals from a variety of sources. These sources include septic tank or other on-site waste disposal system failure in dry weather, sewer leaks, permitted and unintentional discharges, unauthorized and unauthorized disposal, and interactions between plumbing and storm sewers. Connections, and poorly or improperly managed livestock and pets. Useless wastewater is a potential entry point for chemicals used on a daily basis in homes, businesses, and agriculture. These substances include pharmaceuticals for humans and animals, hormones, detergents, antiseptics, plasticizers, flame retardants, pesticides, and antioxidants.

Veterinarian drugs directly contaminate soil via manure and surface and groundwater via runoff from field, in addition to human consumption and waste, and the disposal of drugs used in agriculture, industry, and medicine. Das pharmaceuticals and personal care products(PPCPs) are in the process of being treated, but the main pathways for PhPs to enter the environment are emissions from pharmaceutical industry wastewater into wastewater treatment plants(WWWTPs) and municipal sewage.

Many of the compounds released are not biodegradable, making it difficult for conventional(primary, secondary, and tertiary) treatment methods to remove them effectively. It is unclear how much of them are removed. Large amounts of waste liquid are produced during the discontinuous, multi-step pharmaceutical manufacturing process. The results of this study also imply that as PhP develops and advances, production and dosing will rise. PhP lifestyle and longevity are ranked the best globally.

2. LITERATURE REVIEW

2.1 sources of pharmaceutical waste

Water systems are primarily discussed in the majority of published articles on human medications, and wastewater is typically though to be the main source of emissions to the environment because it releases medications either in their natural form or as metabolites. Generally speaking, sewage treatment plant(WWTPs) are not adequately built to remove pharmaceuticals entirely. Wastewater form wastewater treatment is a well-known source of pharmaceutical entirely. Wastewater from wastewater treatment is a well-known source of pharmaceuticals and personal care products(PPCPs) entering environment plant (ARAs).

Through seepage from underground sewage systems, PPCP can also enter water systems. Susmita colleagues employ combined sewage overflow(CSO). His primary sources of PPCP is the pharmaceuticals industry. In 2010, the new your city department of environmental protection calculated the presence of PPCPs in the city’s water supplies and discovered 14 of the 72 target compounds. Human recreation and entertainment activities like bathing, swimming, and other contemporary processes are other ways that humans enter aquatic ecosystems.

2.2 Occurrence/ generation of pharmaceutical waste

Different pharmaceuticals, including analgesics, antibiotics, and stimulants, are present in the resources and soil. A single, distinguishable source of pollution, like a pipe or drain, is what the Victorian environmental protection authority refers to as a point source. This method is typically used to release industrial waste into rivers and oceans. The EPA controls the disposal of waste at high-risk locations through the facility's permit and licensing system, as well as associated compliance and enforcement actions.

Point sources of pollution, also known as diffuse pollution, describe inputs and effects that spread across a large area and are difficult to link to a single source. They are frequently connected to particular land uses, unlike individual point emissions, which are not. The European environment agency states that a variety of activities without a single emission point can result in diffuse pollution. Diffuse pollution is primarily brought on by agriculture, but it can also be caused by cities, forestry, air debris, and rural housing. Pharmaceuticals enter the environment through both point and diffuse sources, which are both significant entry points. The literature has recently reported on the discovery of numerous pharmaceuticals and metabolites in a variety of aquatic environments.

2.3 Characteristics of pharmaceutical wastewater

Pharmaceutical wastewater typically has a complex composition, a high level of organic matter, a microbial toxicity, a high level of salt, and a low biodegradability. Additionally, the majority of pharmaceutical factories use different raw materials and manufacturing techniques, operate in batch mode, and produce a wide range of different effluents.

Additionally, different pharmaceutical wastewater types have different properties. Biopharmaceutical wastewater exhibits high volumetric variation, low C/N, high SS and sulfate concentrations, complex composition, high biotoxicity, and high colour saturation. Chemicals are high in salt, low in nutrients, poorly biodegradable, and toxic to microorganisms.

The effluent characteristics of herbal medicines include sugars, glycosides, organic pigment, anthraquinones, tannins, alkalinity, cellulose, it contains lignin, and other organic matter. biological treatment is common in domestic and international pharmaceutical wastewater because it is the most economical method of removing organic contaminants. Organic matter is therefore the main contaminant in pharmaceutical wastewater.

2.4 Risk of Pharmaceutical Waste

According to studies, developing nations may face higher environmental risks than developed nations dure to drug use and emissions into ecosystems. Living things can be mutagenic and genotoxic when exposed to them. According to some studies, people who reside close to the pharmaceutical industry are susceptible to waterborne illnesses brough on by water pollution. Hypertension, gastroenteritis, heart disease, fetal maternal death, diabetes mellitus, and neurobehavioral disorders are among the illnesses brought on by drug exposure in water. All of these illnesses have been linked to wastewater pollution from the pharmaceutical industry, which creates toxic waste, which is a concoction of inorganic and organic contaminants.

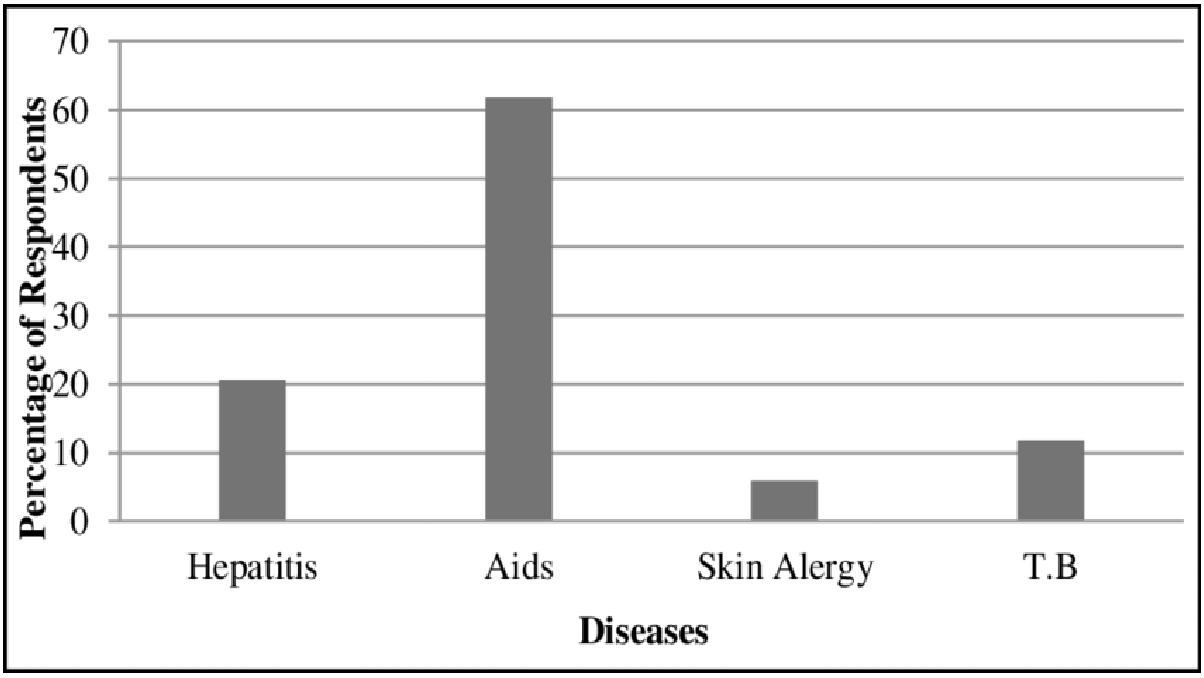

Fig.2.2 Diseases caused by pharmaceutical waste [2.2.1]

These pharmaceutical compounds, which are highly toxic in both nature and concentration, can contaminate all types of pharmaceutical waste, whether they are aquatic or terrestrial. Biological activities that are harmful to environmental systems and that are typically included in pharmaceuticals include lipophilic, non-biodegradable properties.

2.5 Methods of Advanced treatment of pharmaceutical wastewater

In recent years, the focus of scientific research and technological application has shifted to advanced treatment of pharmaceutical wastewater, where the main methods are physicochemical techniques. This means that wastewater is treated by physical or chemical processes such as coagulation sedimentation, flotation, activated carbon adsorption, advanced oxidation processes and membrane separation.

1.Coagulation Sedimentation

Coagulation involves adding chemicals to wastewater and rapidly mixing and dispersing them to convert stable contaminants into unstable, sedimentary substances. The coagulation mechanism is complicated. The key to advanced pharmaceutical wastewater treatment is how to extrude and remove bound water around hydrophilic colloids

The flocculation effect is therefore influenced by the flocculant's characteristics, which are significant. Flocculants include polymers and salts of inorganic metals. Through this technique, toxic organics, SS, and chromaticity can be eliminated. Additionally, it can increase the biodegradability of pharmaceutical wastewater. The most typical method used after coagulation is sedimentation. Denser contaminants have advantages over wastewater sedimentation methods, such as simple operation and established technology, but it is challenging to remove dissolves organic matter.

2. Flotation

Except for sedimentation, flotation can also be used to remove suspended solids from secondary wastewater. A feature of this technology is that by blowing air into the sewage, many small bubbles are generated, forming floating flocs with a lower density than the sewage. And it can float on the surface of sewage for separation.

3. Activated Carbon Adsorption

Adsorbents like activated carbon have many benefits. It has a sizable specific surface area, a multi-level pore structure, a high adsorption capacity, and stable chemical properties**.** As a result, it is frequently used as a catalyst support or adsorbent for pollutant removal. It is a crucial technique for the sophisticated treatment of wastewater from pharmaceutical manufacturing. Activated carbon's adsorption is broken down into. Two types of adsorption are physical and chemical. There is no selectivity for adsorption and physisorption is reversible. It is simpler to desord activated carbon once it has become saturated with adsorbates. Chemisorption, in contrast, only allows him to adsorb one or more particular adsorbates. It is difficult to remove and irreversible.

4. Advanced oxidation processes

Advanced oxidation processes (AOP) that can oxidize contaminants through the formation of free radicals. These types of contaminants cannot be decomposed by conventional oxidants. His AOP comes in a variety of forms, including B. wet air oxidation, supercritical hydroxylation, ozonation, Fenton's reagent, photocatalytic oxidation, ultrasonic oxidation, electrochemical oxidation, and ultrasonic oxidation.

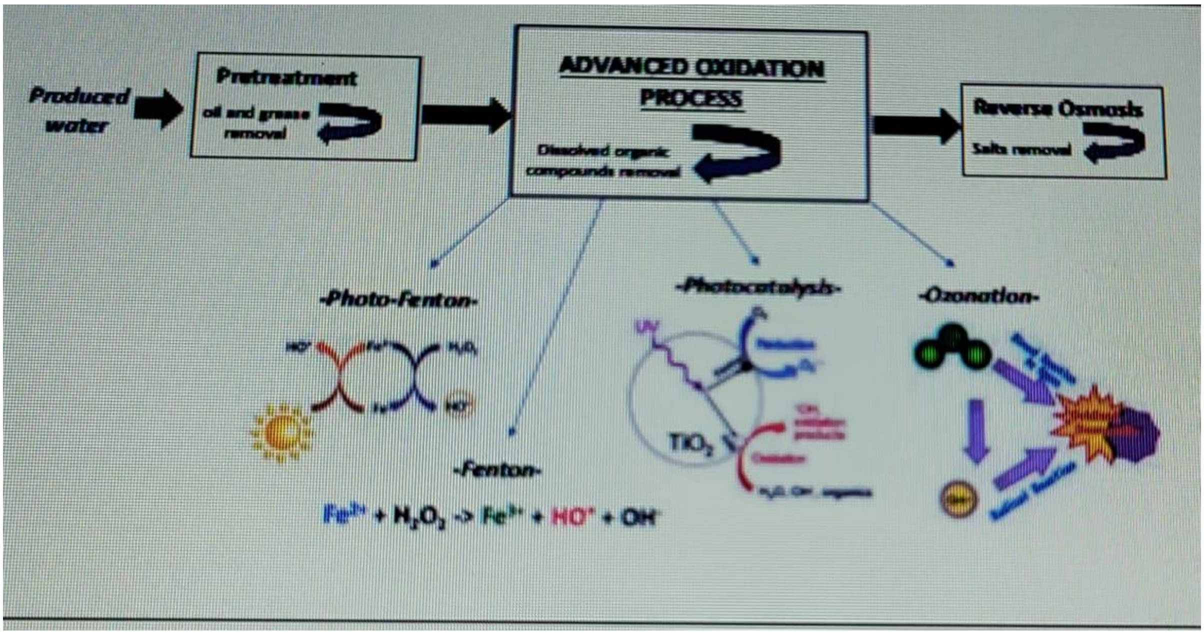

Fig 2.3 Activated oxidation process

2.6. Minimizing Pharmaceutical Waste

Substitution with less hazardous drugs has inherent limitations when designing and implementing pharmaceutical waste management programs, as the hazards of chemicals often have therapeutic benefits. However, cutting waste can lessen risks, expenses, and compliance problems. Several shrieking option are presented in the following section for your consideration.

1. Consideration of Life Cycle impacts in the purchasing process.
2. Maximizing use of opened chemotherapy vials.
3. Enforcement of Sample policy.
4. Labelling of OTC Medications.
5. Filling and Flushing Infusion Lines with Saline.
6. Relevant to Use Consideration of container size.
7. Replacing Pre-packaged single-dose liquids with patient-specific oral syringes.

- The cost of this treatment technology is typically higher than conventional disinfection techniques, even though heat treatments like incineration are applicable to all types of medical waste aside from infectious ones. However, it remains the most common method of treating medical waste in developing countries. Treatment of ash and gaseous pollutants like furans, dioxins, and mercury present challenges for incinerators. Additionally, incineration has the benefit of reducing the processed product's volumetric size by 90%. Gasification, pyrolysis, and plasma treatment procedures used to make bricks are some additional thermal techniques that are infrequently used to treat medical waste. The sludge in the brick product was found tp have significant compressive strength properties in 10% of the cases. Since readily available industrial sludge is used in this process, the cost of the finished product is significantly lower than with conventional feedstocks, and the yield of conventional feedstocks is also significantly lower, making it extremely cost-effective. Illegal disposal of unused medicines has proven to be a major problem in many developed countries.

2.7 Methodical ways to Neutralise pharmaceutical waste

- Various new technologies are being created to treat and neutralize pharmaceuticals in wastewater. These innovations will significantly increase the rate at which drugs are removed from sewage and have a bright future.
- The following processes are among them advanced oxidation processes(AOP), ozonation, direct photolysis, oxidation, TIO2 photocatalysis, Fenton reaction, solar catalysis, and ultrasonic irradiation. Connecting these methods is extremely difficult. To increase therapeutic efficacy and identify the compounds that degrade, the costs involved, and the viability of overall application, more research in this field is therefore required.
- Many researchers and businesses are working to develop alternate technique for processing infectious medical waste due to the negative effects on health and the high cost of medical waste from incineration. The autoclave procedure is currently a recognized substitute for incineration. This method involves heating infections waste with dry heat or steam unit it reaches a temperature that kills any microbial contamination. Most of the time, these systems function between 121 and 16 C.
- There are no pollutants like mercury, furans, or dioxins released into the environment when medical waste is autoclaved as opposed to incinerated, which is another benefit. As a method of disposing of infectious waste, autoclaving has disadvantages similar to those of incineration. While eliminating pathogens without directly burning the waste, the autoclave process keeps the waste's original appearance.
- It appears as though untreated infectious waste is being dumped in landfills because treated waste isn't any different from untreated infectious waste. Even for pharmaceuticals and personal care

items. Even in ecosystems with low levels of PPPCPs, ongoing exposure to these chemicals poses a serious issue with unknowable long-term complications.

3.EXPERIMENTAL WORK

Experiment:1

- Expired vitamins and calcium supplements can be used in moderation as manure in the garden, according to research on the use of expired multivitamins.
- Essential nutrients like vitamins and minerals play a critical role in promoting the proper growth and development of plants. Vitamin B1 encourages the growth of roots and flowers, while calcium strengthens the root system. Vitamin B12 leads to nutritious leaves, and zinc sulfate monohydrate synthesizes essential proteins for chlorophyll production. Vitamin C regulates cell growth and division, and folic acid promotes lush foliage. Vitamin B2 improves drought tolerance, nicotinamide supports overall growth, and vitamin D3 accelerates root formation. A balanced supply of these nutrients is crucial for optimal plant growth and productivity.

Experiment:2

- Transform medical plastic bottles into hanging planters for your patio, kitchen window or garden. Recycle and grow a variety of plants or flowers to add color to your home.
- Medical plastic bottles are a cost-effective and reusable option for growing plants while reducing waste. However, texture, pattern, color, and thickness variations require preliminary operational testing. This project aims to repurpose plastic beverage bottles as organic flowering plant containers, supporting the growth of native, high-quality flowers

Experiment:3

3.1. Materials required:

- Silver recovery from used x-ray film using Nitric acid

1. Waste x-ray films (36.9g,61.5g.76.03g)

2. Oxalic acid (0.1 N)

2. Sodium hydroxide (0.1N) (40g of NaOH in 1L solution.)

3. Nitric acid (100ml)

4. Distilled water (100ml)

5. Ethanol (CH3OH) (200ml)

6. Sodium nitrate ($NaNO_3$) (0.12,0.21,0.28g)

7. Muffle furnace (up to 800°C)

8. Laboratory heater (temperature range 150°C)

3.2. Silver recovery from used x-ray film using Oxalic Acid :

1) X-ray films with mud, rust, dust or other foreign particles are washed with water to remove them and prevent further reactions.

2) Both sides of the X-ray film can be treated with ethanol, which can be removed with a gelatine layer. Alternatively, the films can be used without ethanol for further processing.

3) Cut ethanol-impregnated film to desired size.

4) Damp films cause processing issues, requiring drying before use to prevent further problems during processing.

5) Dry cut films in 50˚C oven for 20 mins..

6) Dissolve 40g NaOH pellets in 1L solution to prepare 0.1N NaOH..

7) Heat the NaOH solution in a heater and when it reaches 60-70˚C, submerge cut material films to remove gelatinous layers on X-ray films.

8) Once the gelatine layer is removed, the films will exhibit a colour change from dark grey to light sky-blue. The solution is then drained, and the films are taken out. It is important to cool down the hot NaOH solution at this point.

9) Upon cooling, solid particles with a dark grey colour will settle at the bottom of the beaker, and it may take up to two hours for complete settling. Alum may be added to the solution to enhance the settling rate.

10) To efficiently remove silver from used films, oxalic acid treatment is carried out. However, to recover a higher amount of silver, nitric acid is a better compound than oxalic acid or sodium hydroxide. Therefore,

the treated films are further treated with nitric acid. This process ensures maximum recovery of silver from the used films while minimizing the amount of waste generated from the process.

11) Once the solids in the solution have settled, filter paper is used to filter any remaining solids from the solution.

12) The residue collected on the filter paper is transferred to a crucible and dried either in a hot air oven or by exposure to sunlight.

13) After drying and weighing the solid powder, it is transferred to a crucible and mixed with an equal amount of sodium thiosulfate and sodium nitrate.

14) Blend all dry chemicals to achieve a consistent mixture.

15) The mixture is heated at 750°C for 20 minutes in a muffle furnace.

16) After cooling for 30 minutes, the crucible is removed from the oven and the powder material is allowed to cool. Silver crystals can be easily observed in the burnt powder.

17) One can retrieve a large silver crystal from the burnt powder, and filter out the remaining silver crystals.

18) 20 mL of 0.1N sodium thiosulfate solution is added to burnt powder for dissolution, followed by filtration. The silver particles can be easily observed after the burnt material dissolves in the solution.

19) Once dissolved, filter the solution through filter paper to separate the silver crystals from the burnt material.

4.Results

- Expired multivitamin capsules can be repurposed as plant fertilizer. Calcium-based supplements aid in avoiding stunted plant growth and promote the development of new leaves and tissues. For weak and lanky plants, adding a few zinc tablets to the water assists in converting starch to sugar, resulting in improved plant health. Instead of discarding unused supplements, they can be used for sustainable plant care.
- A drip irrigation system was set up using saline or glucose bottles to provide a steady water supply to plants. The bottles were refilled daily, and this method saved water while preventing drought damage. By using this system on 0.1 hectares of land, a profit of Rs 15,200 was achieved. This

method was cost-effective and also repurposed waste plastic bottles that would have otherwise taken a long time to decompose in landfills. It also prevented medical waste from being wasted.

- Silver recovery from used xray film using borax method

Feed (g)	Initial silver (g)	Silver recovered (g)	Silver Recovery (%)	Yield (gm) based on feed quantity (g silver/g feed)
36.9	0.738	0.12	16.3	0.0033
61.5	1.23	0.21	17.1	0.0034
76	1.52	0.28	18.4	0.0037

Table 4.1 Borax method calculation and the corresponding Ag recovery for each run.

Initial weight = 2% of feed weight (literature)

1) Feed vs Yield
2) Feed vs Silver Quantity (g)
3) Feed vs Silver Recovery (%)

Formulas :

% Yield = gram of silver removed /gram of feed * 100

% Recovery = gram of silver recovered /gram os silver present in feed

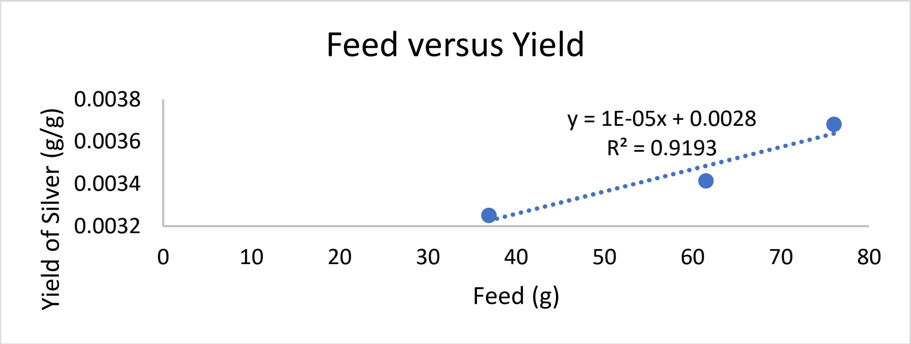

Fig:4.2 Feed versus yield

Graph of Feed vs Yield shows that as the mass of films is increased ,the yield of silver increases. It is known as Data fitting -Mathematrical model which is equation related input with output.When 36.9g ,61.5g ,76gram of feed was taken,yield came out to be 0.0033g 0.0034g,0.0037g. The R^2 value is 0.9193.

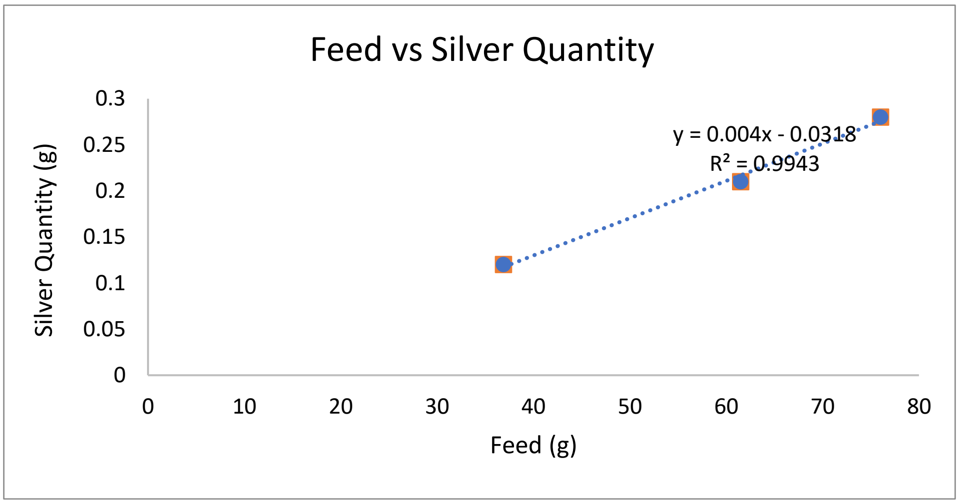

Fig :4.3 Feed vs Silver Quantity

Graph is between Feed vs Silver quantity R^2value is 0.9943 when different gram of feed was taken .It is a linear graph .The R value implies that method is significant.

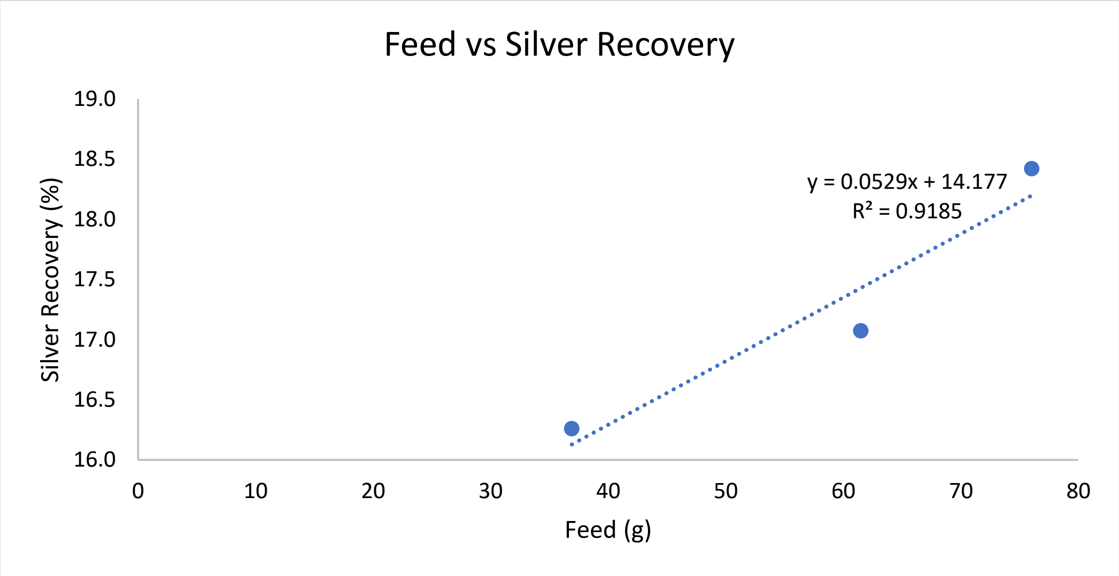

Fig:4.4 Feed vs Silver Recovery

It is a linear graph between Feed vs Silver Recovery .The R^2 value is 0.9185. For significant process ,R^2 value should be > 1.As feed amount increases ,rate of silver recovery increases.

4.Conclusion

- Compliance with food and drug authority regulations in various countries and maintaining acceptable water quality standards for use, discharge or reuse within pharmaceutical manufacturing facilities is essential. The presence of specific waste contaminants and regulatory restrictions necessitate the use of significant amounts of ultrapure water.
- Limits on water discharge into communities and streams may exist, and pharmaceutical products may be released into the environment due to use and improper disposal from manufacturing facilities. Many pharmaceutical manufacturing plants have been identified as sources of pharmaceuticals in the environment, with the majority of them coming from chemical synthesis and fermentation process effluents.
- Manufacturing facilities produce significant quantities of waste during their processes, cleaning, washing and upkeep.

5.Future scope

i. Conservation of a precious metal, economic return, and environmental concerns.
ii. It can be repurposed for industries such as medical, military, aerospace, and others.
iii. Switch from disposal to utilization
iv. Sterilize and recycle waste
  - Optimize the process to reutilize as much waste as possible
v. Create a cost-effective process
vi. Save money, preserve landfill space, follow regulations.

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