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Effectiveness of Filtration Methods (Coffee Grounds and Silica Sand) in Reducing Iron (Fe) Levels in Leachate Water: Literature Review

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ABSTRACT
Background: Open dumps cause leachate pollution so that the complex composition of leachate including organic and anotorganic chemical content gets more attention for processing. Coffee grounds and silica sand have the potential to become filter media in reducing Fe pollutants in leachate at final disposal sites (TPA) because of their efficiency in removing heavy metals.
Methods: Potentially eligible studies were identified from Proquest, Wiley, Google scholar, and Elsavier databases over the last ten years. The search strategy consisted of terms (Filtration Method, Leachate, Silica Sand, and Coffee Grounds). Then data extraction was carried out based on the inclusion criteria and then entered into Mendeley. The selected articles aim to investigate/detect filtration methods in leachate water.
Results:. Heavy metals have harmful effects on ecosystems and human health because they are biodegradable. Adsorption in the filtration method absorbs certain substances due to the attraction of atoms or molecules. Activated coffee grounds act as active carbon which adsorbs Fe levels. Silica sand has surface characteristics that can be used as a filtration medium. Findings from the articles reviewed indicate that coffee grounds and silica sand have the potential to be used as filter media to reduce Fe concentrations in leachate water.
Conclusion: The filtration method using coffee grounds and silica sand shows effectiveness in reducing Fe levels in landfill leachate water.

Keywords: Leachate, Filtration, Coffee Grounds, Silica Sand

INTRODUCTION

Landfills or open waste dumps are a common practice for dumping around the world. Currently, sanitary landfill is the most commonly used method for solid waste disposal worldwide if properly designed and operated. Landfill can eliminate some of the detrimental impacts resulting from other solid waste final disposal alternatives such as burning in open kilns and open pits [1]. However, other impacts may arise from the formation of gas and leachate if not controlled properly. These impacts include fires and explosions, vegetation damage, unpleasant odors, landfill settlement, groundwater pollution, air pollution and global warming [2].

In developing countries, landfills are largely unsuccessful because landfill sites have a limited time frame for use. It also accepts solid, commercial and industrial waste which may contain hazardous substances and may increase health risks originating from leachate and gases[1]. The leachate pollution index shows that young landfills from the tropical rainforest zone and tropical monsoon zone have higher pollution potential. Pollution potential in the tropical savanna zone does not show a significant difference in pollution potential in terms of landfill age. Considering the landfill's operating method, open dump sites pose a higher potential for pollution.

Positive correlations can be seen between biological oxygen demand, chemical oxygen demand, total dissolved solids, and total nitrogen [3]. Leachate processing has received more attention from researchers because of the relatively small flow rate and complex composition of leachate. The selection of a good leachate processing technology depends on the main parameters of the leachate such as BOD, COD and heavy metals [4][5]. Adsorption, coagulation, flocculation, chemical precipitation, membrane separation, ion exchange, and electrochemical technology are examples of conventional methods. In some circumstances, this procedure produces rapid results, although it is less efficient and costs more than biotechnological heavy metal removal [6].

Although leachate is characterized by a high content of organic and inorganic chemicals as well as toxic properties arising from heavy metal concentrations, groundwater through monitoring wells in the vicinity of certain wells exceeds WHO and EPA standards. These parameters include conductivity, total dissolved solids, chloride, sulfate, manganese and iron [1]. Heavy metal pollution is a widespread concern [7]. Fe and Mn concentrations were measured using the Atomic Absorption Spectroscopy (AAS) method. After filtration processing, Fe and Mn levels can be reduced to 0.072 mg/L and 0.012 mg/L. The results showed that the concentrations of Fe and Mn were below the threshold for Minister of Health Regulation no. 492/Menkes/IV/2010 0.3 mg/L Fe and 0.4 mg/L for Mn. In this case, the effectiveness in reducing Fe and Mn ions can be 92.46% and 98.82%, respectively.

This implies that sand has the potential to be used as a filter media to reduce Fe concentrations. A combination of adsorbents is used or the discharge must be reduced to increase the removal yield and reduce the output pollutant concentration to an acceptable level [8]. Generally sand filter materials appear to be a good choice for removing metal solutes. The results showed that modified silica showed higher iron removal efficiency due to its surface characteristics. The research results also showed that at an adsorption time of 60 minutes and pH 7, the maximum iron removal efficiency of 99.99% and 99.98% was obtained using modified silica at a dose of 0.4 mg/l and 0.2 mg/l respectively. l.

The surface of the silica adsorbent material is composed of oxygen atoms, and the bonding is confirmed on the tetrahedral part of the silica and the hydroxyl groups that bind the specific edges of the silicate structural units. These useful groups provide shallow sites for metal ions. The surface hydroxyl groups dissociate into natural water and act as Lewis bases towards metal ions. Metal surface bonding reactions (adsorption) are usually preferred by metals due to their hydrolysis properties [9]. In addition, a slow sand filter designed with a predetermined thickness can reduce iron levels by 95.07%, manganese levels by 97.09%, and fecal coliform levels by 99% [10]. Besides silica sand, activated carbon is a widely available material that has been used for water treatment already in the 19th century. It is produced by heating coal, peat, or wood in the absence of oxygen.

Activated carbon adsorption has been reported as an effective method for removing high molecular weight refractory organic materials from aqueous solutions. Adsorption is a process of absorption by certain solids of certain substances that occurs on the surface of the solid due to the attraction of atoms or molecules on the surface of the solid without seeping in [11]. Activated carbon has been widely used as an adsorbent, catalyst and catalyst support in various environmental applications such as the removal of harmful pollutants [12] [13]. One potential source of activated carbon is coffee, which is produced everywhere throughout the world and has a high annual production resulting in large volumes of residue; in fact, every year, approximately 30 million tons of solid waste from the coffee industry is generated, and most of it is disposed of inadequately[14]. Compared with the use of dissolved acids, coffee grounds have more efficiency in removing metals, such as Al, Ca, Co, Fe, Mn, Ni, and Zn. However, Fe removal was significantly reduced when higher weight/volume of coffee grounds was introduced.

Metal recovery, as well as removal of dissolved metals from drainage water, illustrates the effectiveness of the proposed approach for coffee grounds reuse[15]. Carbon material derived from biowaste is used as an adsorbent for water treatment because it has the advantages of being cheap, abundant and environmentally friendly. in particular,among the methods for removing organic dyes from wastewater, through filtration, ion exchange, oxidation, electrocoagulation, etc. The adsorption method is the most economical and effective technique [16] [17]. Carbon activation from coffee grounds can be done conventionally or chemically. After activation, all powders showed high carbon content and rather small fractions of other elements. This confirmed the carbonization process was successful in all cases[18].

The carbon contained in coffee grounds plays a role in binding metal ions in the adsorption process [19]. Adsorption of metal ions by coffee grounds is best explained by the Langmuir model, chemisorption is the dominant type of adsorption [20]. The size, structural integrity, and increased heterogeneity of surface functional groups of coffee grounds may also facilitate further modification to increase the adsorption ability of contaminants during processing [21]. In previous research with the aim of converting used coffee grounds and parchment into active carbon through a calcination process, the results of used coffee grounds and parchment showed a yield of 9.0% after calcination and washing treatment [22]. Scanning microscopy of the activated carbon material confirmed that calcination together with calcium carbonate improved the pore structure compared to the raw material. The characteristics of the prepared activated carbon show similarities with the available forms [23]. Used coffee grounds and parchment were found to have similar adsorption efficiency to commercial activated carbon for total removal of phenol and protein content from wastewater.

MATERIALS AND METHODS

Literature sources mainly come from online database journals that provide free journal articles in PDF format, such as: Proquest, Wiley, Google Scholar, and Elsavier. There is a limit to the year of publication, namely articles from the last 10 years that are relevant to the research topic so that the information remains up to date.

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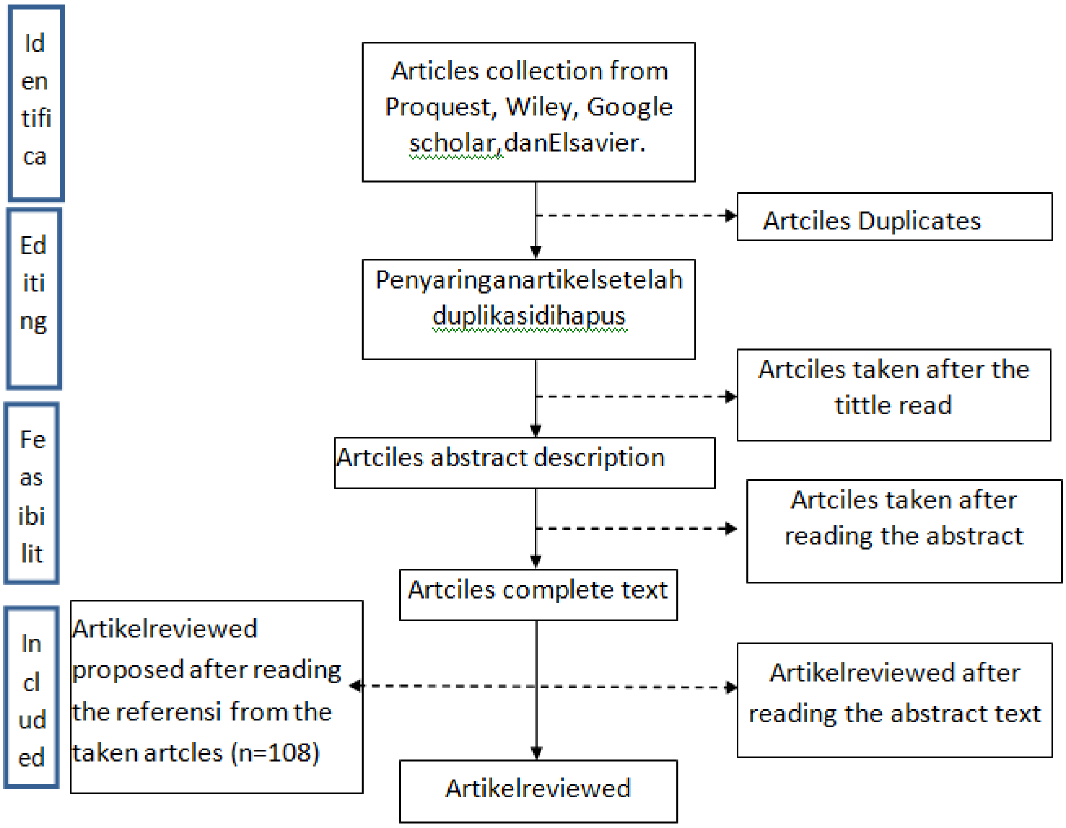

Figure 1: Literature Flowchart

RESULTS

Based on the literature study carried out, it was found that leachate can include various pollutants originating from waste that can be transferred to the soil. Treatment of wastewater containing heavy metals can be done physically, chemically or in combination. Activated carbon from coffee grounds is a good medium for the absorption of the heavy metal iron.

Table 1: Literacy Description of Environmental and Health Risks in Leachate Water

No	Author, Year	Objectives	Method	Results
1.	Borhan Mansouri, Javad Salehi, Mehri Rezaei, 2014, Iran [24]	To calculate the content of heavy metals including Pb, Cd, Cr, Cu, and Ni in well water located downstream of the compost factory and landfill leachate fromMasyhad, Iran.	Qualitative study, In both winter and summer 2009 samples were collected from five wells located at the downstream landfill in Mashhad.	Among heavy metals, nickel concentration in summer and lead concentration in winter have the highest levels. The results showed that the average heavy metal concentrations in the wells studied were below the national drinking water standards of Iran, WHO, and the United States. The Pearson correlation coefficient also indicates a significant correlation between the metals in the well.

2.	S.K. Maiti, et al., 2016, India [25]	To characterize leachate and its impact on water resources around a closed dump site in Dhapa (Kolkata, West Bengal, India).	Qualitative study, leachate samples, one groundwater sample (tube well) and one surface water sample (pond) were collected from the landfill and its surroundings during the pre-season, monsoon and post-monsoon of 2013 and 2014.	Laboratory analysis showed the prevalence of high values of TDS (8994.16±6239.2mg/L), COD (4191.66±2282.19 mg/L), NH4 +-N (1165.93±658.4mg/L), Cl (4356.65 ±1304.84mg /L) and two heavy metals viz. Pb (0.56±0.33mg/L) and Hg (0.42±0.44mg/L) in leachate samples that have exceeded the respective quality standards specified in the "Municipal Solid Waste (Management and Handling) Rules, 2000" for discharge of treated leachate. The maximum concentration of heavy metals mentioned above is. T and mercury were found to be 0.15±0.18 mg/L and 0.16±0.28mg/Soil 0.23±0.21 mg/L and 0.1±0.05 mg/L respectively for sources surface water and groundwater power which have exceeded the respective permissible limits recommended by the Bureau of Indian Standards (BIS). The level of pollution of local water resources requires proper processing of leachate before disposal and establishes the importance of closed disposal management posts.
3.	Omobolaji O. Afolabi a, et al., 2022, Nigeria [26]	To assess the potential for environmental pollution due to leachate produced from abandoned landfill systems and assess human health risks from groundwater around the landfill.	Qualitative study, research samples include leachate from three abandoned landfills and nine (9) groundwater samples from nearby boreholes around the landfill. All samples for the study were collected in November and December 2020 using appropriate collection techniques.	Estimated Total Carcinogenic Risk (TCR) for carcinogenic metals (As, Cd, Cr, Ni, and Pb) from various landfills shows no carcinogenic risk (TCR < 10 − 6). Although abandoned landfills show potential for environmental pollution and groundwater contamination; however, a health risk assessment of the groundwater revealed no significant carcinogenic risk to exposed populations. Therefore, it is necessary to treat water and evaluate the pollution status of landfill soil.

Table 2. Filtrasi Air Limbah

No	Author	Objectives	Method	Results
1.	B.S.R. Nanayakkara, et al., 2020 [27]	To investigate the performance of several cheap/waste materials as filtration media in anaerobic filters to treat organic compounds, nutrients and heavy metals found in landfill-leachate.	Eksperimental	During the application of 10% aqueous landfill-leachate over a period of 115 days, the overall removal efficiency of the filter bed with layered media was 73%, 84%, 61%, 55%, 76% and 79% for COD, BOD5, TN, Ammonia-N (NH3-N), TP and Orthophosphate-P (PO43- -P), respectively. Mixed media provided overall removal efficiencies of 59%, 87%, 49%, 26%, 71% and 78% for COD, BOD5, TN, NH3-N, TP and PO43- -P, respectively. The experimental column showed significant removal efficiency of heavy metals namely Pb (40%), Cd (48%), Cu (41%) and Mn (52%) in the mixed media column and (54%), Cd (37%), Cu (54%) and Mn (57%) in the layered media column.

2.	Bambang Murwanto; Agus Sutopo; Prayudhy Yushananta, 2021 [28]	To determine processing efficiency and to compare the processing efficiency of filter materials that people choose from expensive and conventional filter materials, and to study the variations in the physical and mechanical properties of the selected materials due to interaction with landfill-leachate.	Eksperimental	During the application of 10% aqueous landfill-leachate over a period of 115 days, the overall removal efficiency of the filter bed with layered media was 73%, 84%, 61%, 55%, 76% and 79% for COD, BOD5, TN, Ammonia-N (NH3-N), TP and Orthophosphate-P (PO43- -P), respectively. Mixed media filter beds provided overall removal efficiencies of 59%, 87%, 49%, 26%, 71% and 78% for COD, BOD5, TN, NH3-N, TP and PO43- -P, respectively. The experimental column showed significant removal efficiency of heavy metals namely Pb (40%), Cd (48%), Cu (41%) and Mn (52%) in the mixed media column and (54%), Cd (37%), Cu (54%) and Mn (57%) in the layered media column.
3.	Filippo Fazzino, et al., 2021 [29]	The feasibility of integrated treatment was investigated in the laboratory scale uses synthetic leachate with the aim of maximizing recovery potential beneficial compounds present in the leachate (especially ammonia nitrogen).	Eksperimental	After 38 days, the best performance in terms of cumulative methane production (5.3 NL) and methane yield (average 0.26 NL/gVS added) was recorded in the reactor fed with the lowest dose (17.9 mL/day) of MLL pre-treatment by ZVI/lapillus filter. The main issue that arises during AD is the possible inhibition of processes related to the excessive presence of humic substances; However, in subsequent experiments, this problem can be solved through optimizing the management of the entire process.
4.	F. Fazzino, et al., 2021 [30]	To determine possible new strategies for processing and validation of urban waste streams in the perspective of a circular economy.	Eksperimental	During anaerobic digestion, granular activated carbon (GAC) is added in some reactors along with the feed solution (substrate and pretreated MLL) to retain possible flame retardants or toxic compounds and to facilitate the activity of microorganisms by promoting interspecies electron transfer. The direct mechanism of MLL, is used as a nutrient solution, produces a stable AD MW with a methane yield of around 0.260 NL/gVSadd. GAC proved also efficient in increasing methane production to higher methane yields (approximately 0.302 NL/gVS added) obtained in reactors where it was added as a supplement.

Table 3. Activation of Coffee Grounds as Activated Carbon

No	Authors	Objective	Subject	Results
1.	Sekirifa Mohamed Lamine, et al., 2014 [31]	To test the effectiveness of coffee grounds as an adsorbant supporter phenol at room temperature.	Coffee residue, a low-cost agricultural by-product, was tested as a precursor for the production of porous carbon in chemicals. Scheme using phosphoric acid.	Activated carbon was obtained at 600°C and 700°C for one hour 5 (°C.min-1) in the presence of adjuvant percentages of approximately 5,678 and 12.78% giving specific surfaces of 176 and 186 m2/g, respectively. The resulting adsorption capacities were 52.63 and 55.56 mg/g respectively. This adsorption is compatible with the Langmuir and Freundlich models with a correction factor R2> 0.92.
2	Alivia Mukherje , et al., 2022 [32]	To assess the potential of used coffee as a precursor for the production of	Used coffee as a precursor for the production of activated carbon (AC)	This study assesses the economic feasibility of three scenarios for activated carbon production. Scenario 1 includes a slow pyrolysis and CO2 activation unit. Additionally, an exhaust gas recycling unit

		activated carbon (AC) through technology thermochemical conversion.		was implemented. Scenario 2 consists of burning flue gas while the third scenario consists of burning flue gas and eutectic solvent in impregnation.
3	Jessica M. Steigerwald, Jessica R. Ray. 2021. [21]	To produce and characterize biochar coffee grounds for PFOS adsorption	Activated Coffee Grounds in PFOS adsorption	KOH-activated coffee grounds present an attractive alternative to existing commercial charcoal adsorbents. Widely available raw materials and low-input production processes can make these materials a viable water treatment option.

DISCUSSION

Leachate can include a variety of pollutants originating from waste that can be transferred to the soil. Nevertheless, no adverse effects were observed regarding the transfer of pollutants in this field test. However, it must be taken into account that the composition of leachate is inherently variable, so continuous monitoring will be necessary to guarantee in terms of possible migration of metals, pathogens and other contaminants [33] [34]. This can be attributed to landfill operations and waste management practices in municipalities, especially in terms of reverse logistics and selective collection of metal-rich recyclable materials, which are important as preventive measures to protect against soil and water contamination [35]. Using only biological processing of leachate, it is practically impossible to reach the discharge limit, and this is especially true for mature leachate.

In the last decades, special attention has been paid to combined methods of leachate processing using biological, physical and chemical [36] [37]. The process of selecting a methodology for leachate treatment is usually determined by factors such as: type of adsorbent, sludge production, type of filter, type of coagulant and optimum dosage, type of activated sludge, treatment time, and process sequence, must be considered [38] [39] [40]. Adsorption techniques are recognized as an efficient and promising basic approach in wastewater treatment processes. It is used as a stage of integrated chemical-physical-biological methods for leachate processing, or in conjunction with biological processes [41]. The leachate filtration process is preferred compared to other processing methods due to its high efficiency, ease of operation and ability to process liquid processing [42] [28]. Filtration processes such as microfiltration (MF) and ultrafiltration (UF) have proven effective in industrial wastewater treatment, including oil-water separation, as they produce permeate qualities suitable for water reuse applications [43]. Efforts to control metal ion waste have recently increased, encouraging the search for new methods that are cheap, effective and efficient. One way is to use activated charcoal as a medium to adsorb metals [44]. The harmless treatment of landfill leachate membrane filtration concentrated solution should be realized by combining the advantages of different processes with the combination of various processes to solve the existing problems and obstacles of each process [45].

After treatment by adsorption, the Fe concentration in the final waste was determined and it was observed that the Fe concentration was reduced [46] [29]. In filtration the efficiency of reducing Fe concentration is higher than in sedimentation tanks, because the process that occurs in filtration is more effective if less coagulant is added, the influence of contact time from the above results at both outlets does not really affect it [47]. Iron (Fe) is a metal with atomic number 26, atomic mass 55.85 g/mol, and melting point 1536 °C. If iron is in water, the iron will be suspended and have a brownish color. The suspension formed will clot and settle at the bottom of the water body. So alternative adsorbents are needed to adsorb iron solutions, one of which is activated carbon [48].

As time goes by, the demand for activated charcoal continues to increase, but the main ingredients such as coal, wood and coconut shells are becoming increasingly unavailable. This makes it possible to make activated charcoal from biomass waste such as straw, olive stones, nut shells, coffee grounds, and seeds [49] [50]. Coffee grounds, which are the soluble residue of the coffee industry, are highly polluting due to the presence of organic materials that require large amounts of oxygen to be degraded. Coffee is one of the most important agricultural commodities in the world because it is one of the leading commodities, a brewed drink made from roasted beans [31].

It was noted that samples from coffee waste were characterized by higher heterogeneity of functional groups and lower levels of aromaticity [51]. Mass spectrometry analysis of the studied materials revealed higher macromolecular heterogeneity in the composition of coffee and tea samples compared to wood biomass[52]. Coffee grounds have a high amount of organic content, are available locally and there is a large amount of waste material from coffee shops that can be converted into value added products. Additionally, only a small sample size of coffee grounds is required to prepare the activation process [53]. Coffee is used as a raw material to produce activated carbon by carbonization [54]. The physicochemical properties of biochar originate from the slow pyrolysis of used coffee grounds [32]. The low levels of water content and ash content and high ion absorption capacity indicate that the surface of the coffee grounds activated charcoal used has wide pores so that it can provide a large opportunity for adsorbates to fill the activated charcoal pores and increase adsorption capacity [55] [56]. The greater the concentration of Fe (II) metal and the adsorption temperature, the more the adsorption efficiency of activated carbon will decrease. Literacy results show that previous research activated carbon is a good medium in the process of absorbing the heavy metal iron. Previous research succeeded in characterizing and testing the absorption ability of activated carbon from empty oil palm fruit bunches to effectively absorb the heavy metal iron [57] [58].

Silica sand is widely found and because of its porosity and high surface area, silica sand is widely used as an adsorbent in refining processes. Silica is a type of white sand made in sizes of 0.2 to 0.4 mm. Natural white silica affects the absorption of iron and uranium, and also other parameters such as the amount of adsorbent, temperature and so on to find optimal conditions [59]. When using silica sand, the pollutant content decreases because the adsorption capacity of silica sand is able to absorb suspended solids in water [60]. Sand filters were studied as an inorganic example and because of their frequent application in the treatment of leachate and rainwater [61]. The high concentrations of heavy metals and organic compounds reported here may have harmful effects on ecosystems and human health. Through oral administration of contaminated water, heavy metals can be transported to humans and accumulate toxicity. Therefore, health and environmental concerns regarding heavy metal contamination are of great concern issu among health communities, especially in developing countries where some forms of pollution are widespread [62-71].

CONCLUSION

The filtration method using coffee grounds and silica sand shows effectiveness in reducing the Fe content of landfill leachate. Activated carbon has been widely used as an adsorbent, catalyst and catalyst support in various environmental applications such as hazardous pollutants. One potential source of active carbon is coffee. Coffee grounds have a lot of efficiency in reducing heavy metal levels.

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