ADSORPTION TREATMENT OF LANDFILL USING LOW COST ADSORBENT- REVIEW

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Abstract- The most cost-effective, popular, and favored form of solid waste management is landfilling. Despite the many benefits of landfilling, the production of highly contaminated leachate is a significant disadvantage. Mismanagement of leachate can result in a variety of health risks, beginning with contamination of groundwater and surface water. Landfill leachate has been treated in a variety of ways, ranging from biological to chemical to a combination of both. However, new research has discovered that activated carbon adsorption has special features that can remove contaminants from landfill leachate. Recognized as the most acceptable method for removing refractory compounds in aqueous and actual effluent due to its ability in terms of physical and chemical sorption, as the most anticipated treatment method that has been studied using a wide range of precursors derived from natural resources, synthesized materials, and agricultural wastes, as the most anticipated treatment method that has been studied using a wide range of precursors derived from natural resources, synthesized materials, and agricultural wastes. The purpose of this research is to examine the various agricultural wastes that are utilized as precursors in the production of activated carbon for the treatment of landfill leachate. In addition, the main breakthrough of activated carbons adsorption with an emphasis on low-cost precursors, implementation obstacles, and future expectations will be highlighted.

Keywords- Landfill; Leachate Treatment; Activated Carbon; Low-Cost; Adsorption

I.INTRODUCTION

Environmental protection has become a subject of major concern recently, especially through the worldwide perspective. The pollution of the environment has reached a point where it needs to be investigated and addressed, otherwise it'll cause catastrophes within civilizations. There are many sorts of pollution but, the main concern of researchers and scientists focuses on water pollution. Water is indeed, the foremost basic requirement in order to sustain the natural ecological processes. However, deteriorating quality of unpolluted water sources have become a serious concern because clean and hygienic water source is that the only thanks to ensure healthy lives of human beings and ecosystem longevity. The challenges of removing various sorts of pollutants from water have become harder thanks to the rapid industrialization era especially affecting those in developing countries. Pollutants namely heavy metals, phenols, dyes, inorganic ions and pesticides are present within the wastewater streams of the many industrial processes which can affect water bodies, groundwater and therefore the environment. In the past decade, the worldwide population has grown exponentially, although it increases productivity, it also increases the consumption habits that cause rapid generations of municipal and industrial solid wastes.

Worldwide, the foremost used strategy of MSW management is sanitary landfilling. Landfilling is recognized as a proper method of disposal thanks to its simpler operations and cost-effectiveness (Kamaruddin et al., 2017). The components of MSW play a crucial role in determining the suitability of the disposal systems and methodsconsistent with Visvanathan et al. (2004), despite their high moisture content, most Asian countries' solid wastes, such as rubbish, paper, plastic/foam, agriculture waste, rubber/leather, wood, metal, glass, and textiles, are highly biodegradable. Therefore, identifying the foremost suitable alternative for future solutions for MSW management is crucial like landfilling, incineration, composting and others. Landfilling of wastes cause two sorts of pollution; a) the water that percolates through the wastes from rains, contaminating surface and groundwater, is known as leachate, and b)Biogas, which is formed by the fermentation of organic matter caused by discarded trash, pollutes the air.(Abdulhussain, 2009). Groundwater is one among the main sources of water used for drinking and daily usage in communities round the world. A crucial natural resource which is a smaller amount polluted compared to surface water thanks to its ability to self-cleanse and simple treatment (Oluyemi et al., 2009)

Before discharging into open water, the generated leachate must be treated and suits standards established by the authorized bodies. There are various methods of leachate treatment systems implemented, although advanced leachate systems do exist, the obstacle for landfill operators are the high capital costs and specialized management required for the upkeep of the system. Thus, research is required to establish a selective and reliable alternative method to treat heavily polluted leachate. Activated carbon adsorption on landfill leachate has been used in a variety of research, the majority of which have used commercial activated carbon. Activated carbon adsorption on landfill leachate has been used in a variety of research, the majority of which have used commercial activated carbon(low cost adsorbent). This review aims to supply an in-depth development of adsorption using activated carbon, particularly activated carbon derived from agricultural wastes.

II. LITERATURE REVIEW

- **OPTIMIZATION OF PREPARATION CONDITIONS FOR ACTIVATED CARBON FROM BANANA PSEUDO-STEM USING RESPONSE SURFACE METHODOLOGY ON REMOVAL OF COLOR AND COD FROM LANDFILL LEACHATE (2017)**

Zaidi Ab Ghani , Mohd Suffian Yusoff , Nastaein Qamaruz Zaman , Mohd Faiz Muaz Ahmad Zamri , Jeyashelly Andas

The optimal conditions for the preparation and adsorptive treatment of landfill leachate using banana pseudo-stem based activated carbon were identified in this work. The combination effect of three major reaction variables, namely activation temperature (°C), activation time, and impregnation ratio, was optimised using response surface methodology (RSM) based on Box-Behnken (IR).

The reaction was carried out in a closed activation system with a single stage of $ZnCl_2$ activation. The RSM based on BBD was found to be particularly relevant for adsorptive removal of pollutants from landfill leachate treatment in a series of 17 separate trials.

The optimum conditions obtained by Design of Experiments (DOE) was at 761°C activation temperature, 87min activation time and 4.5g/g impregnation ratio with product yield (27%), iodine number (1101mg/g), color removal (91.2%) and COD removal (83.0%).

- **PREPARATION OF ACTIVATED CARBON FROM SUGARCANE BAGASSE BY MICROWAVE ASSISTED ACTIVATION FOR THE REMEDIATION OF SEMI-AEROBIC LANDFILL LEACHATE (2013)**

K Y Foo, L K Lee, B H Hameed

This study assesses the adsorptive removal of ammonical nitrogen and orthophosphate from semi-aerobic landfill leachate using sugarcane bagasse derived activated carbon (SBAC) produced by microwave heating.The findings demonstrated the utility of activated carbon produced from sugarcane bagasse for the adsorptive treatment of semi-aerobic landfill leachate.

- **COMPARISON STUDY OF AMMONIA AND COD ADSORPTION ON ZEOLITE, ACTIVATED CARBON AND COMPOSITE MATERIALS IN LANDFILL LEACHATE TREATMENT (2010)**

  Azhar Abdul Halima, Hamidi Abdul Azizb, Megat Azmi Megat Joharib, Kamar Shah Ariffinc

In terms of adsorption isotherm and kinetics, this study looked at the adsorption properties of ammoniacal nitrogen and COD in semi-aerobic leachate from the Pulau Burung landfill site on zeolite, activated carbon, and a novel composite media.According to a comparison study, composite adsorbent had a higher adsorption capacity for ammoniacal nitrogen than zeolite and activated carbon, and was similar to activated carbon for COD.

- **INFLUENCE OF WASTE AGE ON LANDFILL LEACHATE QUALITY (2010)**

  Aik Heng Lee, Hamid Nikraz, Yung Tse Hung

The impact of trash age on leachate characteristics from a landfill site with young and mature waste cells was researched over a six-year period to assess the impact of waste age on leachate quality. The study's findings demonstrated that trash age has an impact on leachate quality due to its effects on bacterial development and chemical reactions in landfill waste mass.

- **LANDFILL LEACHATE TREATMENT: REVIEW AND OPPORTUNITY (2007)**

S. Renou, J.G. Givaudan, S. Poulain, F. Dirassouyan, P. Moulin

The purpose of this study is to provide an overview of landfill leachate treatment options. Following the state of the art, a debate will bring to light an opportunity, and some results of the treatment process will be performed. Under each topic, the benefits and cons of the various treatments are described. Several tables allow you to look through and summarise each treatment efficiency based on the operational parameters.

- **AN OVERVIEW OF LOW-COST ADSORBENTS FOR WASTEWATER TREATMENT (2015)**
  Sabino De Gisi1, Giusy Lofrano, Mariangela Grassi, Michele Notarnicola

The goal of this work was to review the current literature on the use of low-cost adsorbents for wastewater treatment, stressing both adsorbent properties and adsorption capacities in a systematic manner. Low-cost sorbents have been split into five categories for this study: Agricultural and domestic wastes, industrial by-products, sludge, sea materials, soil and ore materials, and innovative low-cost adsorbents are all examples of low-cost adsorbents.

- **REVIEW OF LANDFILL LEACHATE TREATMENT(2019)**
  Yun Wang, Qin Fang, JieJin

With the advancement of science and technology, leachate treatment methods improved, and the management system became more efficient. The study summarises the current state of leachate treatment technology, including physical, chemical, and biological treatment methods, and concludes that the technology can be improved. The document also discusses the benefits and drawbacks of each method, as well as future application possibilities.

- **SELECTION OF THE ACTIVATED CARBON TYPE FOR THE TREATMENT OF LANDFILL LEACHATE BY FENTON-ADSORPTION PROCESS (2007)**
  Liliana, San-Pedro,Roger, Méndez-Novelo, Emanuel, Hernández-Núñez, Manuel, Flota-Bañuelos, Jorge, Medina,Germán Giacomán-Vallejos

The adsorptive ability of two forms of activated carbon, granular and powdered, was investigated in this study to see which was more efficient in the Fenton-adsorption process' adsorption stage. Similarly, its behaviour was investigated using three isotherm models (Langmuir, Freundlich, and Temkin), with the raw and Fenton-treated leachates being tested with both carbons. The findings demonstrate that granular activated carbon is more efficient than powdered activated carbon at eliminating chemical oxygen demand (COD), whereas powdered activated carbon is better at removing color.

- **LEACHATE TREATMENT TECHNOLOGIES (2013)**
  Sameer Kumar, Dhruv Katoria and Gaurav Singh

An overview is given of landfill leachate treatment methods including advantages and disadvantages of different approaches. Various solutions including coagulation flocculation, adsorption by activated carbon, biological treatment, and reverse osmosis are discussed. From the study they concluded that the most worthy technologies according to Indian standards are Coagulation and Flocculation, Biological treatment, Rotating Biological Contactor (RBC).

- **COFFEE PROCESSING WASTEWATER TREATMENT: A CRITICAL REVIEW ON CURRENT TREATMENT TECHNOLOGIES WITH A PROPOSED ALTERNATIVE (2019)**
  E. M. Ijanu, M. A. Kamaruddin & F. A. Norashiddin

The review examines a few of the current methods (physicochemical and biological) used in coffee wastewater management, as well as their benefits and drawbacks, such as high cost, complex operation, and increased time consumption, among others; additionally, the review suggests that the ion exchange technique is a better alternative due to its ability to act as both an ion exchanger and an absorber.

- **POST-TREATMENT OF LANDFILL LEACHATE USING RICE HUSK ASH AS ADSORBENT MEDIUM (2019)**
  Josian Pinheiro, FariasLarissa, LoebensCarolina, Faccio, DemarcoTito, Roberto

The ideal operational condition for slurry treatment employing a fixed-bed column was determined in this investigation. The study found that using activated rice husk ash as a post-treatment for stabilized landfill leachate is a viable strategy for COD reduction, apparent and true color. For the investigated conditions, the experiment revealed a clearance efficiency of more than 60%.

III. LANDFILL LEACHATE

A. LANDFILL LEACHATE STUDIES

Landfill leachate is rainfall flowing through wastes within a landfill or dump, accumulating dissolved and suspended components from biodegrading wastes through physical and chemical processes. The liquid formed by precipitation percolating through an open landfill or the cap of a completed site may contain massive amounts of pollutants such as organic substances measured as chemical oxygen demand (COD) and biochemical oxygen demand (BOD), ammonia, high concentrations of heavy metals, and inorganic salts (Renou et al., 2008, Foul et al., 2009, Aziz et al., 2009, Uygur and colleagues, 2009). It is produced by excess water percolating with a mixture of organic and inorganic loads within the trash layers of the landfill, producing a quantity of leachate that is dependent on the amount of rainfall (Azmi et al., 2015).

Landfill leachate is divided into three categories based on the age of the landfill: young, medium, and old, also known as stabilised leachate (less than a year, 1-5 years and more than 5 years, respectively). Landfill leachate is one of the most difficult effluents to biologically treat (Matoi et al., 2008). Because of the degradation of trash by the soil, the landfill experiences chemical and physical changes. As a result, when rainfall is added to the liquid percolating, chemical, physical, and biological reactions occur with the wastes within, affecting the quantity and quality of the leachate produced. According to Kamaruddin et al. (2015), the quality and quantity of leachate produced is affected by landfill age, precipitation, weather changes, waste type, and composition.

Landfilling has been practised for many years, dating back to 1935. Periodically, trash was tossed into a pit and covered with earth. This method was used without a barrier or underlying layer (line) to prevent percolating water from contaminating the groundwater as it passed through the wastes. The early deployments of landfills were considered as garbage dumping grounds, but this concept has evolved due to the harmful environmental repercussions of these landfills, as discovered by many research. Landfilling has a number of severe environmental consequences, including leachate contamination of surface and groundwater, pest infestation, and the release of environmentally harmful gases such as hydrogen sulphide and methane into the atmosphere (Ojeda-Benítez and Beraud-Lozano, 2003, Scharff and Jacobs, 2006, Buivid et al., 1981, Haivadakis et al., 1988). Sanitary landfilling, described as an engineered way of disposing of wastes, was established in the 1950s. It was common practise to dispose of waste by uncontrolled tipping or dumping, an operation in which waste is dumped to fill a pre-existing hole or on low-value land, without regard for the environment, which included the need for daily waste covers and the prevention of leachate spreading into waterways (Blight, 2008). Today, scientific, engineering, and economic approaches are being applied to the structural transformation of landfills, with leachate monitoring being undertaken frequently by landfill operators and mandated by authorities.

B. LANDFILL COMPONENTS AND ENVIRONMENTAL EFFECTS

The state and sorts of processes occurring within a landfill can be determined by analysing the composition of leachate produced by landfills. The composition of leachate created from industrial, commercial, and municipal wastes can be classified i nto dissolved organic matter, inorganic matter, heavy metals, and xenobiotic chemicals, depending on the type of sanitary landfi ll used (Christensen et al., 1994). Organic pollutants including dissolved organic matter assessed in terms of COD and BOD, ammonia, methane (NH4), humic and fulvic-like chemicals representing the decomposition of organic wastes in landfills may be found in high concentrations in leachates. Furthermore, a significant portion of landfill leachate is made up of inorganic constituents such as magnesium (Mg2+), calcium (Ca2+), potassium (K+), sodium (Na+), iron (Fe2+), chloride (Cl-), sulphates (SO42-), and bicarbonates (HCO3-) with the presence of heavy metals (arsenic, cadmium, chromium, cobalt, lead, mercury, copper, Meanwhile, xenobiotic substances are present as a result of municipal and industrial chemicals (Aziz et al., 2009, Renou et al., 2008).

Several researches have observed that landfill leachate has negative environmental consequences, making it necessary to remediate the leachate according to the local government's requirements and conditions.

For discharge into receiving waters, the Department of the Environment (DOE) is responsible (Renou et al., 2008). Table 1 shows the DOE's standards for discharge into the environment.

Table I Parameter limits of leachate discharge (Department of Environment, 2009)

Parameter	Unit	Standard A	Standard B
Temperature	Degree C	40	40
pH Value		6.0-9.0	5.5-9.0
BOD_5 at 20 degree C	mg/l	20	50
COD	mg/l	50	100
Suspended Solids	mg/l	50	100
Mercury	mg/l	0.005	0.05
Cadmium	mg/l	0.01	0.02
Chromium	mg/l	0.05	0.05

Cyanide	mg/l	0.05	0.10
Copper	mg/l	0.20	1.0
Nickel	mg/l	0.20	1.0
Iron (Fe)	mg/l	1.0	5.0
Phenol	mg/l	0.001	1.0
Chlorine	mg/l	1.0	2.0
Oil and Grease	mg/l	Not Detectable	10

COD, BOD, BOD/COD ratio, total organic carbon (TOC), pH, suspended solids, ammonium nitrogen (NH3-N), total Kjeldahl nitrogen (TKN), bacterial count, turbidity, and heavy metals content (Gotvajn et al., 2009) are the best indicators of landfill leachate characteristics to assess the quality of the produced leachate as well as predict the future composition of leachate and the type of design and The landfill leachate characterization of young and stabilised leachate is shown in Table II.

Table II Landfill leachate characterisation according to composition

Leachate Type	Young	Intermediate	Stabilized
Landfill age yr	<5	5-10	>10
Ph	<6.5	7	>7.5
COD g/l	>20	3-15	<2
BOD/COD	>0.3	0.1-0.3	<0.1
TOC/C0D	0.3	0.1-0.3	0.4
Organic matter	70-90% VFA	-	HMW
Nitrogen	100-2000 mg/l TKN		
Metals g/l	2	<2	<2

IV. Landfill Leachate Treatment Technologies

For many years, wastewater treatment businesses have warned that the release of organic, inorganic, and heavy metal compounds into streams, groundwater, and surface water, in particular, poses a threat to the natural environment and the population. One of the most serious issues linked with landfilling, producing major pollution of soils, surface water, and groundwater. Many recent advancements in leachate treatment research have focused on improving coagulation-flocculation processes, clarification, and biological methods such as activated sludge, aerated lagoons, sequential batch reactors, and so on. However, the main concern for landfill operators is the high capital costs, specialised and costly maintenance, and simplicity of the implemented systems.

Due to the low biodegradability ratio of the local leachate, which means that a biological process alone will not be enough to remove the majority of refractory pollutants, an integrated leachate treatment with other technologies such as advanced oxidation process (AOP) or physicochemical treatments can improve the removal efficiencies of pollutants such as adsorption, which may improve its titer (Kurniawan and Lo, 2009). Biological treatments and physicochemical approaches have long been thought to be the most effective solutions for treating landfill leachates, which are termed high-strength effluents. Biological approaches provide reasonable treatment performance for juvenile leachate in terms of COD, NH3-N, and heavy metals. However, when it comes to treating stabilised leachate that is less biodegradable, physicochemical treatments are thought to be the best option for removing organic refractory compounds.

The integrated chemical–physical–biological processes compensate for the shortcomings of separate processes, resulting in a greater total treatment efficiency. However, with the continued tightening of discharge standards in most countries and the ageing of landfill sites with more and more stabilised leachates, traditional treatments (biological or physicochemical) are no longer sufficient to achieve the level of purification required to fully reduce the negative environmental impacts of landfill leachates. It implies that new treatment options technologies are required.

V. LANDFILL LEACHATE TREATMENT VIA LOW-COST AND COMMERCIAL ACTIVATED CARBON (Adsorbent) ADSORPTION PROCESS

In the past decade, adsorption, a surface phenomenon which is common within the removal of organic and inorganic pollutants where gas or liquids of the mixture is attracted solid sorbent surfaces and attachments are formed through physical and chemical bonds, recognized as a promising and therefore the most effective so far fundamental approach within the wastewater treatment industries (Rashed, 2013). Table 3 summarizes the research on landfill leachate treatment utilizing the activated charcoal adsorption procedure undertaken by various researchers and professionals.

To deal with the temporal fluctuations in varying strength and composition of landfill leachate, the event of collaborated multistage treatments, which combine adsorption processes with numerous complementary approaches have received stern attention and various encourages. Simultaneous adsorption and biological treatment studies are common, and they have a number of benefits, including increased nitrification efficiency, improved sludge dewaterability, and the removal of refractory organic compounds (Aktaş and Ceçen, 2001, Aghamohammadi et al., 2007). The presence of activated carbons in co-treatment processes is thought to contribute a unity effect, which provides a surface for attachment for bio-regeneration of microorganisms and a nucleus for floc formation. (Çeçen et al., 2003). Furthermore, this phenomenon has always been linked to the supporting medium within the biofilm reactors which benefits biodegradation and as dampening effects of leachate within the combined domestic wastewater and landfill leachate systems (Kalderis et al., 2008).

Table III. List of activated carbon in landfill leachate treatment

Activated carbon/precursor	**Leachate Type**	**Pollutant removal**	**Percentage Removal (%)**	**Reference**
Banana frond	Landfill leachate	Boron Total iron	92.7 3.0	Foo et al. (2013)
Banana pseudo-stem	Landfill leachate	Color and COD COD	91.2 83	Ab Ghani et al. (2017)
Carbotech	Intermediate	COD	75	Zajc et al. (2004)
Coconut shell	Young	Ammonia COD	80 70	Halim et al. (2010)

Coconut shell GAC	Young	COD	82	Kurniawan and Lo (2009)
		NH_3-N	59	
Commercial GAC		COD	19.1	Liyan et al. (2009)
		HOC	73.4	
Commercial PAC	Intermediate	COD	75	Uygur and Kargi (2004)
		Ammonia	44	
		Phospate	44	Kargı and Pamukoglu (2004)
	Synthetic	COD	87	
		Ammonia	16	
	Stabilised	COD	38	Hur and Kim (2000)
	Young	Color	50	Aghamohammadi et al. (2007)
		Ammonia	78	
		COD	49	
	Intermediate	HOCs	89.2	Liyan et al. (2009)
		COD	24.6	
Oil palm shell	Stabilized	COD	50	Lim et al. (2009)
PAC-SBR	Stabilized	COD	64.1	Aziz et al. (2011)
		Color	71.2	
		NH_3-N	81.4	
Rice husks	Young	COD	70	Kalderis et al. (2008)
		Color	60	
	Intermediate	COD	90	Lim et al. (2010)
		Nitrogen		

VI. MAJOR CHALLENGES AND FUTURE POTENTIAL

At the instant, we face the worst environmental crisis within the entire history of the planet. Within the last decade approximately, excess waste production and environmental preservation are the best public concern, are one among the foremost challenging topics focused on by scientists and researchers. With new technology that specialize in environment-friendly and sustainability, various research and development efforts are conducted to completely utilize activated charcoal treatments mainly for landfill leachate treatment. During the method of implementing activated carbons, the adsorption capacity is associated closely with the accessibility, stability, and surface properties which include area , pore microstructure, and pore size distribution (Li et al., 2007, Gao et al., 2009). albeit there are successful breakthroughs of industrial-scale applications and implications, there are various challenges that the industry remains facing; the supply of operational technologies that are economical and sustainable natural resources that are obtainable (Yuen and Hameed, 2009).

Despite these shortcomings, the advancing research in evaluating the suitability of natural, renewable, and low-cost materials as alternative precursors has currently ongoing. a good range of approaches has been implemented including physical, chemical, and biological technologies are attracting regeneration and high priorities. Counting on time, place, and context, environmental effectiveness, feasibility, social acceptability, and economic affordability are usually the key factors deciding its flexibility, reliability, and sustainability. most significantly , to realize a well-managed solid waste management system, professional knowledge is crucial to make environmental awareness for adequate financial solutions, engineering and operating standards, responsibility-sharing, public involvement, regular opinion survey, site rehabilitation, and aftercare maintenance got to be properly assigned and managed because, without a correct system, new and sophisticated problems will arise (Bernache, 2003). Additionally, full cooperation and support from the govt. no matter parties which include nations, states, government, private sectors, and communities from top to bottom with compatible technologies may be a step within the right direction for a well-managed and sustainable solid waste management system.

CONCLUSION

Manufacturing and processing industries will continue to grow dramatically over the next decade and beyond, generating large amounts of solid waste and highly polluted wastewaters in the process. It's also expected that during the next 20 years, there will be an increase in waste products, which could lead to leachate penetration. The growing controversy and limited efficacy of remediation in field applications has prompted concerns about the use of activated charcoal or technology related to it as an environmental pollution control technique. When adopted, this new technology has evolved from a desirable alternative strategy to a powerful technique that provides a wide range of benefits. Despite the numerous limitations and problems that have been found and defined, significant and rapid growth in this field is frequently expected in the near future.

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