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Mini Review

RECENT APPLICATIONS OF BIOMASS WASTES IN INDUSTRY FOR ENVIRONMENTAL SUSTAINABILITY

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ABSTRACT

The current work is to provide an overview of the agricultural wastes– biomass wastes, such as corn stalks, straw, nutshells, and forestry residues applications in different industries to sustain the environment.

Literature showed that millions-Ton update estimates potential supplies of agricultural crop residues and wastes. The largest quantities of agricultural residues and wastes are from the major commodity crops. In the past years (on yearly average) there was approximately a million ton of primary dry crop residues that can be utilized, and sometimes make a profit by collecting them at farm gate with feedstock prices of 60 and 50 US Dollars per dry ton. The literature showed also many applications of biomass wastes which are considered as renewable and safe source for many industries such as manufacturing cementitious bricks by direct use or by direct incineration to produce energy, and by using the ash results from the combustion in the concrete matrix, producing energy and power through direct combustion or by producing bio fuel that can be utilized later, using in the water and waste water treatment as adsorbent, fertilizers, animal feed stocks, and extracting industrial chemicals for huge and important application like corrosion inhibitors.

INTRODUCTION

The increase in populations causes an increase in the generation of wastes, rates of generation of many types such as the industrial, municipal, solid, and agricultural wastes, etc. This in turn causes a serious need to have reliable management system, policies, and standard procedures both, on long term and on short term basis. It is expected that in 2025 that population of the world will reach approximately 8 billion, where 5 billion will live in urban areas. In addition to what is known as mega-cities where most of them are located in South-East-Asia (Mavropoulos, 2010; Mills, *et al*., 2010).

The expected amount of municipal waste will exceed 1.8 million ton/day in the coming 10 years (Hoornweg and Bhada-Tata, 2012). International conventions state regulations to protect the environment and are setting tighter restrictions on industries to achieve higher standards for more environmental friendly products. Hence, the problem of coexistence of sustainable industry and safe environment are among challenges for most industrialized countries in the scene of fuel prices and availability (Bani-Hani, *et al*., 2016). The traditional means to manage the municipal wastes in developing world is direct dumping and land filling (Menikpura, *et al*., 2016). Other municipalities and large industrial plants are applying Rotary-kiln incinerator as a method of safe disposal of hazardous wastes (Bani-Hani, *et al*., 2016).

The 3 Rs principal which is Reduce, Reuse, and Recycle encourages the reduction of the amount of wastes instead of recycling them (Gertsakis and Lewis, 2003) which has a strong relationship with the sustainably in addition to the low prices of such wastes, its availability, and renewability. If the producer responsibility to adapt a proper management of the wastes he produces and

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considering the recovery techniques which includes extracting a key substance (which can be used later in an industrial application) from the wastes before the safe disposal, then there is a 5Rs principal that is, Responsibility, Reduce, Reuse, Recover, and Recycle will be a more sustainable solution for modern communities. So this work provides an overview of some up-to-date applications where the agricultural wastes are used, which in turn serves the hierarchy of waste management that is (reuse) before applying the last step in the procedure of waste management i.e., the disposal.

LITERATURE REVIEW

Industrial applications of agricultural wastes

Literature shows traditional applications of agricultural wastes in industry to fulfill the hierarchy of waste management, such as in food, energy, fertilizers, etc (Doelle, 2016). As mentioned earlier the amounts and types of wastes generation is increased, a real need for more practical and suitable management techniques appear to sustain environment. Below are some up-to-date applications of agricultural wastes in addition to a brief review of traditional ones.

Water and waste water treatment

Water treatment using agricultural wastes can be performed either by direct use of the waste or by preparing industrial adsorbents that used to treat water from different pollutant like heavy metals and dyes. Fruit stones from food processing industries, are used to produce carbon with good strength and porosity which will make it suitable to be used in absorption processes, the quantities of fruit stones are enough to produce the carbon on commercial base (Heschel and Klose, 1995; Mechati, *et al*., 2015). Examples of such fruit stones are stones of peach, apricot, olive, cherry, grape, and date (Ahmed, 2016).

The agricultural wastes can be used directly to treat water; researchers (Talokar, 2011) had a study aimed at efficiency evaluation of water treatment using non-conventional low cost adsorbents, such as fly ash powder, Straw Dust, Saw dust, and Coconut coir. They compared the results to the powder activated carbon for the removal of chromium Cr(VI) from aqueous solution. The efficiency of the adsorbents for the removal of chromium was investigated. It was found that the waste organic materials are easily and very cheaply available everywhere, and are efficient in removing the contamination. Hence they can be utilized as adsorbents. All tested adsorbents followed Langmuir adsorption isotherm.

Other researchers worked in using the agricultural wastes to remove more hazardous pollutants from water like lead (Pb2+) (Barbosa, *et al*., 2014); where fly ash produced from the combustion of biomass wastes to treat industrial waste water containing Pb2+ even at high concentrations. The tested concentrations of Pb2+ were (1, 10 and 1000 mgPb2+/L). such industrial waste water that contains this high concentration of lead ions are from battery factories, where the effluent after treatment showed a drastic reduction of the lead ions concentrations.

In a previous work, researchers (Barbosa, *et al*., 2013) biomass fly ashes are analyzed to investigate the composition through an acidic digestion (USEPA Method 3051A, 2007), leaching behavior (EN 12457-2, 2002); and particle size to select the best specification for optimum water treatment. Treating water by removing heavy metals is one of the important studies all around the world, the industrial development cause a lot of these heavy metals to escape to water bodies and heavily polluted industrial water. One main biomass wastes from rice crops is investigated for its power in removing the heavy metals from industrial waste water. Results showed high removal percentage of heavy metals using rice straw (Kulkarni and Vijayanand, 2010). Examples of heavy metal removal using rice straw are chromium Cr(VI) and nickel Ni(II) by adsorption (Wu, *et al*., 2016). Researchers varied adsorbent dosage, initial acidity of the solution, temperature and concentration. The results showed rice straw is very efficient in removing the heavy metals and the adsorption isotherm is The adsorption data were suitable for Langmuir isotherm model.

Cement industry

The concrete production sector has many challenges starts from raw materials and energy, and its adverse effects on environment (Teixeira, *et al*., 2016). The agricultural wastes can be used either as a source of energy by direct combustion and/or producing an alternative fuel for the industry or by using the bottom and fly ash as component in the concrete matrix which will minimize the need for raw materials (Tarelho, 2012) which will contribute to the economical sustainability of saving money to buy raw materials and environmental sustainability by using wastes instead of disposing them. Literature shows that the use of pozzolan as from biomass in concrete could have positive results (Barbosa, *et al*., 2013; Monshi, *et al*., 2013; Cheah and Ramli, 2015; Cordeiro, *et al*., 2009; Rajamma, *et al*., 2009; Wang, *et al*., 2008)

Construction materials

Researchers investigated experimentally and analytically the use of rice straw in manufacturing bricks for building (Garas, *et al*., 2015). they investigated the mechanical properties and sustainability of the bricks. The concentrations of rice straws in the bricks matrix is changed, the properties are tested for each concentration to find the optimum concentration that gives the best properties according to certain codes of building. The optimum concentration is found to be 40 kg/1000 bricks using the same quantity of cement with the same amount of fine aggregate.

Similar study (Avelar, *et al*., 2016) used the bio sludge was mixed with cotton textile residues in different ratios to produce briquettes different compaction pressures. The heating value, chemical characteristic, density, resistance to compression and hygroscopic moisture equilibrium were analyzed. The compaction pressure of 6205 kPa proved ideal for the briquetting process in the laboratory scale and the best mixing proportion between the two residues was 25% of sludge.

Waste to energy

One of the simplest and oldest means to deal with agricultural wastes is by producing energy from them or what is known as Waste to energy (WtE) (Menikpura, *et al*., 2016), as they have high carbon content. This is now a trend in the world mainly for biomass wastes (Balat, 2011; Balat, 2009). This can be done by either direct combustion or incineration (Menikpura, *et al*., 2016) or by indirect means that include the production of fuel that will be burned later for direct combustion (Maa, *et al*., 2016). In previous work (Zumar, *et al*., 2016) researchers reviewed the potential of energy production from anaerobic digestion of the many types of wastes or biomass. They reviewed different agricultural wastes/ biomass, municipal wastes and industrial wastes, sugarcane as agricultural residues is investigated. The results showed a possibility to produce energy (about 3790 TJ/year) and with huge quantities of this waste residue which can be a sustainable source of energy.

Corrosion inhibition

The possibility of extracting certain chemicals that can be directly used as a substance or used as a reactant to produce a corrosion inhibition substance is found to be high by utilizing the agricultural wastes. Researchers were successful in producing pectin from tomato peel wastes and investigate its application as a cheap source of corrosion inhibitor (Antonela, *et al*., 2016). They applied a chemical treatment procedure to the biomass waste. They investigated the wastes from tomato canning industry and they were successful in developing a new generation of corrosion inhibitors.

Literature also showed that the pectin can be produced from other biomass wastes like Passion fruit peels (Belhadi, *et al*., 2015). Some references (Mohammad, *et al*., 2012; Gervasi, *et al*., 2015) show that pectin from citrus peel is used as corrosion inhibitor for mild steel and aluminum in acidic solutions.

Thermal insulator

In buildings, a need to have good thermal insulations is important. Studies are focusing on using biomass agricultural wastes as thermal insulators to sustain environment as they have low value of thermal conductivity. The vegetal materials were used by human as construction materials (Palumboa, *et al*., 2015). Researchers investigated the effect of adding barley straws on thermo physical properties of sand concrete as construction material (Belhadi, *et al*., 2015). Results showed that thermal conductivity, specific heat and density are improved as insulator.

CONCLUSION

After reviewing the literature about industrial applications where the biomass wastes can be utilized, it is found that because of the good physical and thermal properties of the wastes, many applications can be considered for such materials, starting from using them as insulator because of low thermal conductivities to treat water as adsorbent because of their strength and porosity which provide large surface area for the interaction. Their use as a source of energy as they have high heating values and with their hydrocarbon structure makes them an excellent source of fuel. The huge amounts of wastes produced yearly make them a sustainable and renewable source for different applications.

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