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Bentonite used as natural coagulant and adsorbent: A review

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Abstract
Waste water generation from various human and anthropological activity leads to the generation of waste water and its disposal off into water stream without treatment is an major problem of the every city. Various techniques are used to treat waste water but they are costly and cause various environmental problem. Bentonite is a natural clay mineral available locally at very low cost, eco-friendly and shows excellent adoption of toxic metal, organic matter *etc* from waste water. More focus has been done on modification methods so its adsorption capacity has been increased for pesticides, dye and heavy metals removal.

Keywords: Bentonite, natural coagulant, waste water generation

Introduction
Water is one of the most essential natural resource. Due to industrialization, urbanization and anthropogenic activities large number of contaminants are added into water. The presence of natural organic matter, heavy metals, pesticides, dye and insecticides make the water unfit for human consumption. These pollutants may have adverse effects on human health and aquatic ecosystems (Reddy and Lee, 2012). With the advancement of technology, there is a development of more effective, low cost, robust methods for treatment of wastewater have been used which put low impact on environment and human health. Extensive studies have been undertaken in recent years with the aim of finding alternative and economically feasible technologies for water and wastewater treatment.

Various technologies used for waste water treatment
There are large number of treatment methods which are used to treat wastewater generated from various industries like active sludge, bioremediation, photodegradation, microfiltration, coagulation-flocculation, fenton-oxidation, adsorption and electrocoagulation. Among these, coagulation–flocculation has considerable attention for its high removal efficiency (Vishalia and Karthikeyanb, 2014) [2]. Coagulation is an essential process in the treatment of both surface water and industrial wastewater. Its application includes removal of dissolved chemical species and turbidity from water *via* addition of coagulants (Vijayaraghavan *et. al.*, 2011) [11]. A coagulant is a substance which in solution, furnishes ionic charges opposite to those of the colloidal turbid particles present in water. Coagulants neutralize the charges on the colloidal particles and produce a jelly like spongy mass called a flock. Flocculation causes considerable increase in the density and size of coagulated particles resulting in an effective rate of settling of the particles in a solution or in the wastewater (Verma *et. al.*, 2012) [12]. Coagulants aim to remove pollutant in form of physical (solids & turbidity) or chemical (BOD & COD). (Pearse, 2003) [13]. Conventional chemical-based coagulants, namely, alum ($AlCl_3$), ferric chloride ($FeCl_3$) and polyaluminium chloride (PAC). Although these are effective but have disadvantages associated with usage of these coagulants are ineffectiveness in low-temperature water, relatively high procurement costs, detrimental effects on human health, production of large sludge volumes and the fact that they significantly affect pH of treated water. There is also strong evidence linking aluminium-based coagulants to the development of Alzheimer's disease in human beings. Syntheic polymer like acrylamide as coagulants create the problem of neurotoxicity and carcinogenicity (Yarahmadi *et al.*, 2009) [9]. It is therefore desirable to replace these chemical coagulants with clay mineral to avoid the drawback. Today prime concern for environmentalists is to lower the cost of flocculants and coagulants and safely utilization of sludge.

Recently low cost materials such as peat, clay, soya cake, bone char, plant based coagulants, agricultural waste like rice husk have been used as adsorbent for waste water treatment.

Bentonite clay mineral as adsorbent and caogulant

Clay mineral become popular and widely used as an adsorbent for treatment of waste water containing heavy metal, organic matter, nutrients and pathogenic microorganism (Abdelaal, 2004) [1]. Clay material has been able to adsorbed organic matter due to large chemically active surface area especially for compounds containing amides, amines and polysaccharides (Greenland, 1965) [14]. Clay minerals like bentonite is cheaper, locally available material provide economic techniques.

Bentonite originates from volcanic ash or glass and made up of montmorillonite. Montmorillonite is a hydrous aluminium silicate containing alkali and alkaline earth metal in small amount. Montomorillonite is made up of three layer structure with two layer of silicate enveloped by alumina layer. Bentonite is classified into two types, one is sodium bentonite and another one is calcium bentonite. Sodium bentonite is derived from volcanic ash and deposited in marine environment and high swelling type. Calcium bentonite is derived from volcanic ash and deposited in freshwater environment and less swelling type (Dwairi and Al-Rawajfeh, 2012) [4]. Bentonite consists of aluminium, iron and clay material which are essential compound used for the treatment of waste water. It is found to be best coagulant as it is cheaper and ecofriendly as compared to chemical based coagulant which create environmental problem.

Due to hydrophilicity nature bentonites is not an effective in adsorbing organic compounds. Adsorption capacity has been improved by surface modification by physical or chemical process. In physical process impregnation of organic molecules on clay surface and in chemical process grafting of organic molecules on clay surface. The adsorption capacity can be increased by treatment with strong inorganic acids at high temperature. The bentonite formed after physical, chemical and inorganic acid treatment is known as organo-bentonite which has more adsorption capacity as compared to bentonite.

Organo-bentonite as adsorbent

Modified sorbent such as clay mineral like montmorillonite, kalonite and illite are widely used because of high specific surface area, mechanical and chemical stability and surface and structural properties. Clay mineral modified with cationic surfactant octadecyltrimetylammonium bromide (ODTMA) has been studied by Sanchez-Martion *et al*., (2006) [7] for pesticide removal. Modified clay showed more adsorption capacity than unmodified. Modified bentonite with hexadecyl tributyl phosphonium (HDTBP) or N-cetylperidinium (NCP) used to remove bromoxynil residue form waste water. Modified bentonite showed maximum removal as compared to raw bentonite (El-Nahhal and Safi (2008) [5]. Bentonite in combination with chemical coagulant (PACs) has been used to remove TSS, COD, phosphate ion, nitrogen compounds and toxic metals from municipal waste water by Bourliva *et al*., 2010 [3]. The waste water after treatment has been used for irrigation; swimming and fish water as it fulfil the quality parameter (EPA, 2004). Syafalni *et al.*, (2013) [8] conclude that bentonite can be a good adsorbent for COD removal upto 75%. Best coagulant was mixture of bentonite-zeolite which remove iron (98%) and turbidity (95%) more efficiently. Adsorption capacity has been increase with contact time.

Conclusion

It has been concluded that bentonite provide cheaper, safe, effective and economic method for waste water treatment before disposal to water stream. Clay mineral effectively used for removal of organic matter, toxic metals and nutrients. Modified bentonite showed higher adsorption as compared to raw bentonite. It provides ecofriendly and economic method for the treatment of waste water as compared to chemical based methods.

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