Review on Application of nanofluid/Nano Particle as Water Disinfectant

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***Abstract*-- Nanoparticles like CNT, MgO, silver, Zno, CuO and self-cleaning TiO_2at certain loading showed better activity on reduction in growth of microorganisms. To overcome the undesired properties of nanoparticles they are doped together to form a composite or hybrid to attain the better performance over the various range of bacteria. The nanoparticles were synthesized eco-friendly from natural resources to attain the biodiversity. The antibacterial activity was further measured in terms of COD, MIC, MBC, optical density and UV absorption. The review focused broadly on the single/hybrid/composite nanoparticle based nanofluid for treating wastewater using renewable -solar energy source without any by product recycling problems.**

Key words -- Nanofluid, Nanoparticle, Nanocomposite, Hybrid, Wastewater treatment, MIC, MBC, Antibacterial activity

Nomenclature:

COD : Chemical oxygen demand
MIC : Minimum inhibitory concentration
MBC : Minimum bactericidal concentration
MOD : Margin of deviation

I. INTRODUCTION

Demand for pure water supply and satisfying health standard requirements increased throughout the world due to increment in the population and industrial supplies. The sanitary requirements are one of the important problems faced throughout the world. Various chemicals were used for treating wastewater. But again, toxicity of chemicals impacted the growth of the microorganisms. Various food borne pathogens and water borne microorganisms were affecting human health. Due to ever-increasing microbial resistance to the common disinfectants and antibiotics, numerous studies have been performed to improve antimicrobial strategies. Several valuable studies have been documented in the field of antibacterial nanoparticles in the recent years. Application of metal and metal oxide nanoparticles could be considered as a suitable alternative for some antimicrobial methods. The antimicrobial nanoparticles could be benefitted in the pharmaceutical and biomedical industries for sterilization of the medical devices. These nanostructures could also be directed for preparation of chemical disinfectants, coating-based applications and food preparation processes. Metal nanoparticles (especially metal oxide nanoparticles) show great antimicrobial effects. Improved effectiveness of the metal oxide nanoparticles on the resistant strains of microbial pathogens as well as their heat resistance offer them as potent antimicrobial agents. However, application of some of the metal oxide nanoparticles is limited because of their toxicity at higher concentrations.

It has also proposed that functionalization; ion doping and polymer conjugates of these nanoparticles could be helpful to decrease the associated toxicity. The main aim is to develop a simple and lowcost inorganic antimicrobial agents such as metal and metal oxide nanoparticles as alternative of traditional antibiotics might be promising for future of pharmaceutics and medicine.Brownianmotion van der Waals attraction forces, the effect of surface electrostatic charge, gravitational forces, hydrogen bonding, ionic, hydrophobic and electric dipole moment are significant physical interactions involved in bacterial adhesion to human tissue surfaces. According to the recent research and the last investigations zinc oxide NPs can prevent the spread of infections.

In addition, animal manure is known to harbor a wide variety of microorganisms which can be pathogenic or non-pathogenic to both animals and humans. Foodborne pathogens like Enterococcus faecalis (Hospital infection, Endocarditis Bacteremia, Urinary infection), Proteus vulgaris, Pseudomonas aeruginosa, Serratia marcescens, Salmonella typhi, Staphylococcus epidermidis (Endocarditis, Genital duct infection), Methicillin-resistant, Staphylococcus aureus (Endocarditis, Gastroenteritis, Pneumonia, skin and urinary infections septicemia), Bacillus anthracis (Anthrax Respiratory and gastroenteritis infections), Bacillus cereus (Food poisoning), Streptococcus pyogenes (Sore throat, rheumatoid fever Gangrene, scarlet fever, acute glomerulonephritis) invasion is still a recurrent serious problem faced by the selected community because of the lack of knowledge. The introduction of novel powerful antimicrobial agents is of great importance for the control of pathogenic bacteria, especially antibiotic-resistant strains. Nanotechnology could be one of these potential alternatives. This study focused on nanoparticles (NP) because of its increasing presence in many marketable products and that supports its application in various applications as a reasonably safe agent. The demonstrated antibacterial activity of NP recommends its possible application in the food preservation field; otherwise it can be applied as a potent sanitizing agent for disinfecting and sterilizing food and containers against the attack and contamination with foodborne pathogenic bacteria.

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II. RESULT AND DISCUSSION

[1]formulated ZnO-CNT/PVP nontoxic polymer based nanofluid against disinfecting E faecalis and E coli microorganisms. Results stated that metal oxides based nanofluids were better in controlling the microbial growth. [2], [3] also studied the ZnO nanoparticles at two different sizes for treating effluent containing putida and aureofaciens organisms. Study suggested that bigger size nanoparticle has high COD reduction (97%) compared to smaller size nanoparticle after treatment. [4] performed ultrasonication effect of ZnO nanoparticle on its optical and antibacterial behaviour of E coli bacteria. High nanoparticle concentration and ultrasonication showed better performance compared low concentration. [5], [6]analysed the antibacterial activity of Co-ZnO nanoparticle performance on water borne bacteria at 0-5% of cobalt doping in ZnO nanoparticle.[7] also studied the antibacterial and antifungal activity of ZnO against E coli, L monocytogenes pathogens. Results revealed 58% photoinactivation at 24hr incubation time and 63-80% inhibition at $3x10^{-3}$ to $1.2x10^{-2}$ M nanoparticle concentration.[8] analysed the toxicity of silver, CuO and ZnO on algae, fish, yeast, nematides and protozoa. Results showed ZnO nanoparticles were more toxic to algae compared to other organisms. [9] analysed ZnO/H_2O_2nanofluid at 1µM H_2O_2 and 0.2gm/L ZnO concentration on E coli bacteria. Studies showed better performance for smaller size nanoparticles with better interaction. [10] used ZnO nanoparticle on 9 food borne pathogens and analysed antibacterial assay by MIC and disk diffusion method. ZnO-iron oxide nanocomposite at various ratios 1:9 to 9:1 were prepared and analysed its antibacterial activity on E coli bacteria. > 1:1 Zn/Fe oxide showd better antibacterial activity. [1], [6], [11], [12] studied the effect of shaking speed on disinfectant activity of ZnO nanoparticle on E coli bacteriaand results showed better performance at high speed of shaking.

[13] investigated the silver coated red soil nanocomposite as water disinfectant on E coli bacteria at various fractions of 0.02-0.1 gm/mL at different contact angle 10-30 min. At 0.02-0.1 gm/mL concentration and 10-30 min contact time it showed better results for eliminating E coli bacteria. Author suggested a model with 0.9956 of R^2 value for forecasting the data. [14] also investigated the metal oxide nanoparticle for removing the pharmaceutical waste from wastewater and compared the results with doped metal oxides on various pathogens. [15] also studied the silver nanoparticle performance againstfour pathogens and performed antibacterial activity by MIC, MBC analysis.[16] synthesized silver nanoparticle from Lichen and tested on eight microorganisms.

[17] treated phenol-petroleum wastewater using Fe/Zn nanoparticles by surface methodology and hydrogen peroxide scavenger method. The removal was high at pH 5.23, 50 ppm phenol concentration and 1.57 gm/L nanoparticle concentration for 59 min. [18]developed a novel graphite-poly styrene solvent/water-ethylene glycol based nanofluid and applied on spilled oil for clean-up. It showed low energy surface material as superhydrophobic oil absorbent with good recyclability. [19] used magnet-cyclodextrin hybrid nanoparticle for the adsorption on environmental pollutants and proposed modified models for the hybrid system.

[20]successfully treated E Coli, staphyloccus aureus microbes using reduced graphene oxide/TiO_2 composite at various loading and analysed antibacterial activity by disk diffusion and optical density method. [21] synthesized silver nanoparticle from green tea leaves and performed antibacterial activity ofsilver/water nanofluid by analysing its morphology and rheological behaviour. Results showed that at 0.001 vol%, 10 min ultrasonication time with 36kHz sonication frequency 7.43 adjusted pH nanofluid was stable for 42 stable. [22] analysed the antibacterial activity of Cu-Pd/water nanofluid on E coli, p aeruginosa, e faecalis and s aureus in terms of inhibition zone and MIC. [23]synthesized Fe_2O_3 nanoparticles from guava leaves and studied its antibacterial activity on E coli and s aureus organisms.

[24]–[26] zero valent iron nanoparticle was synthesized by reducing goethite at 550°C was applied on removal of chromium (VI) at various solid loading and reaction temperature results were compared. It showed that they able to reduce chromium (VI) to chromium (III) by increasing nanoparticle concentration from 0.18 to 1.61 mM. [27] studied the CNT usage on fluoride adsorption and mainly focused on the pH of the water and the concentration of nanoparticle. Author also proposed a adsorption isotherm with <19% MOD. [28] studied the performance of CNT for Zn(II) adsorption at various pH and concentration levels. [29] successfully removed CF_4 using CNT by adsorption process. [30] used TiO_2 for treating butachlor solution as a photocatalyst.

TABLE 1
List of Pathogens Treated

Nanoparticle	Micro organism	Antibacterial activity	Reference
ZnO-CNT/PVP	E faecalis and E coli	Well-diffusion, MIC, MBC	[1]
ZnO	putida and aureofaciens	COD	[2]
rGO/TiO_2	E Coli, staphyloccus aureus	Disk diffusion, optical density	[20]
Cu-Pd/water	E coli, p aeruginosa, e faecalis and s aureus	Inhibition zone and MIC	[22]
Fe/water	E coli and s aureus	Agar diffusion and inhibition zone method	[23]
ZnO/water	E Coli	Absorption method, colony count and UV visible absorption method	[4]
Co-ZnO	E coli, v cholerae	Zone of inhibition	[5]
silver	E coli, s tyohimurium, v parahaemolyticus, l monocytogens	MIC and MBC	[15]
ZnO, CuO, Ag	Algae, fish, yeast, nematides and protozoa	MIC	[8]
Silver	P vulgaris, p aeruginosa, s marescens, s typhi, s epidermidis, m aureus, b subtilis and s faecalis	Disk diffusion	[16]
ZnO	E coli	Disk diffusion	[9]

Antibacterial activity methods:

1. Disk diffusion method:

In a typical way, petri dish was poured with nutrient Agar and seeded with the fresh bacteria followed by uniform spread with the help of a spreader. After that, 6 mm round filter paper was dipped in the different compositions of the prepared GTNT composite and placed on the petri dish. The petri dish was incubated for 12-18 hours at 37 °C. After that, the inhibition zones were measured with the help of scale.

2. Minimum inhibitory concentration(MIC):

Smallest concentration of compounds or substance that declines the organism growth in specific media.

3. Minimum bactericidal concentration (MBC):

Turbidity of culture medium in tubes indicates growth of the bacteria spp. As already known, MIC method is the lowest concentration with no growth of bacteria. To determine MBC test, it should be cultured from the last tube without growth on Muller Hinton agar plate then to incubate plate at 37 °C for (24–48) h. If the number of colonies was less than 5 CFU/ml, then the concentration is bactericidal otherwise it would be inhibitory concentration.

4. UV–visible absorption:

UV–vis spectroscopy was used for the comparison of the optical behavior of the sono-synthesized samples I and II. The UV–vis spectra were recorded by a Unico 2800 UV–vis spectrophotometer in the wavelength range of 200–800 nm. For these measurements, the ZnO powders were dispersed in the absolute ethanol in the ultrasonic bath for 5 min at the ambient temperature.

III. CONCLUSION

Various novel nanoparticle-based treatment methods have huge impact on waste-water treatment. Also, toxic nanoparticles are again affecting the environment so choosing the suitable nanoparticle with lesser side effects is most priority. Along with all the capabilities most of the studies are still in the R&D stage, so the impact of the study should reach the industries for the validation and for the betterment of environment diversity.

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