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Combating water quality in domestic wastewater treatment using biowaste material with green synthesis of nanoparticles

***T. DHARANI PRIYA AND A.K. VIDYA**

Department of Biochemistry, Kongu Arts and Science College, Erode (Tamilnadu) – 638104

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ABSTRACT

The present study was carried out during 2018 and 2019 at Kongu Arts and Science College, Erode (Tamilnadu) to demonstrate the use of green synthesis of copper nanoparticle with rice husk ash in water purification process. These nanosorbents in various concentrations (5, 10 and 15%) were used for domestic sewage water treatment. The dissolved oxygen concentration in treated water was found to be increased from 6.78 ± 0.20 to8.41 ± 0.19, 10.28 ± 0.18 and 11.30 ± 0.15 at 5, 10 and 15 % nanosorbent concentration treatments, respectively. Biological oxygen demand and total solids decreased correspondingly from 43.80 ± 0.43 and 430.66 ± 5.81 to a least of 7.63 ± 0.82 and 43.06 ± 2.66 at 15% nanosorbent treatment. Electrical conductivity and total alkalinity were found to be 144.32 ± 3.41 and 41.33 ± 1.33, respectively at maximum nanosorbent concentration. Total hardness, chemical oxygen demand, total dissolved and suspended solids tended to decrease in treated water. Increasing concentration of nanosorbents from 5 to 15% removed substantial amount of pollutants from waste water. The water quality was found to be combated better after the treatment of domestic waste water with 15% nanosorbent concentration. The treated water could be appropriately resolved for its secure discharge into water bodies or used for irrigation and recreational purposes after being verified with regard to desirable or permissible limits as recommended by standard bodies.

Keywords: Rice husk ash, copper nanoparticle, nanosorbent, domestic sewage water

INTRODUCTION

Water conservation promoted the increased use of treated sewage effluent for non-drinking purposes and become the most appropriate solution available to meet the clean water demand. Preparation of novel adsorbents for wastewater treatment using agrowaste inclined the prevailing technologies towards green, sustainable and renewable strategy. Nanobiosorbents are considered as highly lucratives in water remediation (Yunus *et al.*, 2012). Utilization of naturally occuring biomolecules, particularly from plants, in synthesis of nanoparticles opened a new era into the zone of safe nanotechnology and are more economical (Shittu and Ihebunna, 2017). The environmental fate and toxicity of the pollutant material were the deprecatory concerns in selection and design of the material adsorbents employed for water treatment and purification (Bhattacharya *et al.*, 2013). Rice husk ash (RHA), an abundant product obtained by burning of rice husk, can be potentially exploited for effective removal of various pollutants such as dyes, heavy metals, pesticides, organic compounds, inorganic anions from water and wastewaters. As a low-cost adsorbent, RHA was found to be economically feasible option as an adsorbent in batch study to remove selected dye contaminants and pharmaceuticals (Swarnalakshmi *et al.,* 2018). Rice husk and its ash were used as natural coagulants in wastewater treatment (Anjitha and Goerge, 2016). Similarly, rice husk ash as ecofriendly coagulant was employed in dairy wastewater treatment (Ullas, 2018). Copper nanoparticles (CuNPs) are one of the most engineered nanoparticles and also attained prime focus in wastewater purification. The copper oxide nanoparticles proved an effective means of water treatment in the form of adsorbed filter paper strips (Naveed *et al.,* 2019). Copper oxide nanoparticles stabilized with surfactant proved its applicability as a novel wastewater disinfectant (Suleiman *et al.,* 2015). Incorporation of CuNPs enhanced the sludge solubilization due to reduced sludge particle size and also because of interaction between sludge and microorganisms (Berekaa, 2016). CuNPs may increase the antibacterial activity of sorbent materials by disrupting microbial cell metabolism. CuNPs at higher concentrations (30 and 50 ppm) altered specific physicochemical properties of activated sludge (Chen *et al.,* 2014). The synthesis of copper nanoparticles are

Corresponding author e-mail: mail2dharanipriya@gmail.com

cost-effective when compared to nanoparticle synthesis from nobel metals such as gold, silver, platinum and lead. The information available for domestic wastewater treatment with green synthesis of copper nanoparticle using rice husk ash is negligible. So, the present investigation was carried out with an objective to assess the potential use of copper nanoparticle with rice husk ash in combating the water quality in domestic wastewater treatment by evaluating the physicochemical properties of treated water.

MATERIALS AND METHODS

The copper nanoparticle was synthesized by green synthesis method using aqueous extract of rice husk ash. The nanosorbent was prepared using 1 mM copper acetate solution. The synthesised nanoparticles were used as nanosorbents in domestic wastewater treatment. The domestic sewage water samples were collected from household areas before it gets mixed with common drainage. In batch adsorption process, a known amount of nanosorbent (5, 10 and 15%) were individually added to the pooled domestic sewage water samples. The contents were agitated in a rotary shaker at 150 rpm for incubation period of 1 hour. The filtrate obtained after adsorption treatment was then examined for its physicochemical parameters. The samples were named as: untreated domestic sewage water as S1, sewage water treated with 5, 10 and 15% RHA-CuNP as N1, N2 and N3 respectively. The physicochemical parameters viz.colour, odour, turbidity, pH, temperature,electrical conductivity (EC), oil and grease, total alkalinity, total hardness, calcium, magnesium, chloride, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS),total suspended solids (TSS) and total solid concentration were determined using standard methods of analysis of water and waste water as prescribed by ASTM (2003), APHA (2005), Trivedyand Goel (1986), Kodarkar (1992).

RESULTS AND DISCUSSION

Physicochemical Parameter

The results of physico-chemical parameters were presented with the mean values along with standard error in Table 1. All the analyzed values of treated water samples were compared with standard desirable limit as cited by BIS/ICMR/WHO.

Table 1: Physico-chemical parameters for water quality of domestic sewage water before and after treatment with varying concentrations of RHA-CuNP

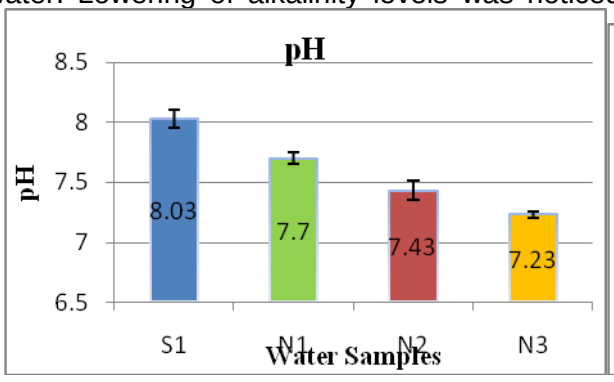
Physicochemical Parameter	Before Treatment (S1)	After Treatment with		
		RHA-CuNP (5%)(N1)	RHA-CuNP (10%)(N2)	RHA-CuNP (15%) (N3)
Colour	Dark Grey	Colourless	Colourless	Colourless
Odour	Musty	Tolerable	Tolerable	Tolerable
Turbidity	Opaque	Translucent	Translucent	Translucent
pH	8.03 ± 0.08	7.70 ± 0.05	7.43 ± 0.08	7.23 ± 0.03
Temperature (°C)	22.00 ± 0.57	18.00 ± 0.28	17.80 ± 0.44	17.90 ± 0.29
EC (µS/cm)	596.59 ± 5.91	246.72 ± 3.41	192.11 ± 5.91	144.32 ± 3.41
Oil and Grease (mg/l)	7.74 ± 0.07	5.10 ± 0.03	2.36 ± 0.06	2.00 ± 0.04
Total Alkalinity (mg/l)	138.66 ± 2.66	67.3 ± 1.76	50.66 ± 1.33	41.33 ± 1.33
Total Hardness (mg/l)	70.19 ± 0.94	56.82 ± 0.19	52.74 ± 0.35	46.92 ± 1.07
Calcium(mg/l)	50.60 ± 0.51	41.62 ± 0.52	39.11 ± 0.21	33.75 ± 1.01
Magnesium (mg/l)	19.50 ± 0.57	15.20 ± 0.34	13.63 ± 0.16	12.83 ± 0.34
Chlorine (mg/l)	154.36 ± 2.74	125.38 ± 1.20	115.92 ± 0.61	98.18 ± 0.61
DO (mg/l)	6.78 ± 0.20	8.41 ± 0.19	10.28 ± 0.18	11.30 ± 0.15
BOD (mg/l)	43.80 ± 0.43	38.30 ± 0.55	17.20 ± 0.77	7.63 ± 0.82
COD (mg/l)	74.80 ± 0.43	54.40 ± 1.66	50.00 ± 1.61	38.13 ± 2.54
TDS (mg/l)	396.00 ± 4.61	122.66 ± 2.66	80.00 ± 4.61	42.66 ± 2.66
TSS (mg/l)	34.66 ± 1.33	0.66 ± 0.13	0.53 ± 0.13	0.46 ± 0.06
Total Solids (mg/l)	430.66 ± 5.81	123.33 ± 2.73	80.53 ± 4.50	43.06 ± 2.66

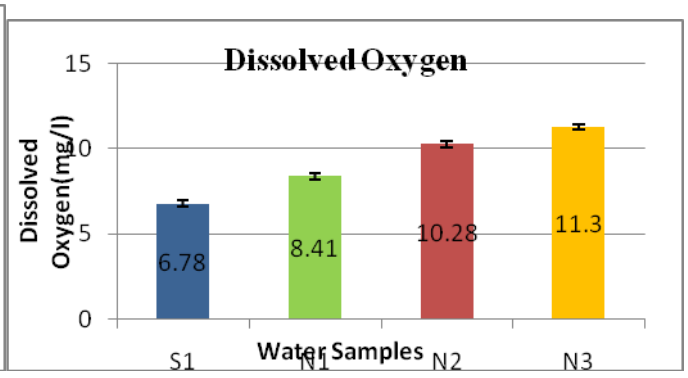
Polluted or sewage water had quite strong apparent and unpleasant colour. The initial colour of the domestic waste water was dark grey, which turned almost colourless in treated samples. Similar results were recorded with rice husk ash as natural coagulant in dairy waste water treatment (Ullas, 2018). Organic compounds, inorganic chemicals, oil and gas might have imparted foul odour in untreated domestic wastewater. The treated water samples have fairly tolerable odour, which may be due to removal of chemical as well as microbial contaminants from wastewater after adsorption by RHA-CuNP sorbent. High turbidity occurs to clogging of particulate materials and also due to presence of organic contaminants. Treated samples were almost clear or translucent in nature. Similar results were reported by Anjitha and Goerge (2016) and Ullas (2018) using rice husk ash as adsorbent at varying dosages and coagulation time.

pH of the wastewater was slightly alkaline, whereas pH of treated samples are close to neutrality and ranged between 7.23 ± 0.03 to 7.70 ± 0.05. pH values of treated water were within desirable limits of 7.0 - 8.5, acceptable for watering green spaces or safe discharge into environment. Reduction in pH was observed when rice husk ash was used as natural coagulant in waste water treatment (Anjitha and Goerge, 2016). The temperature recorded slight reduction after adsorption treatment in treated water samples. The values ranged between 17.80 ± 0.44 and 18.00 ± 28°C, indicating the recognized limit value recommended by WHO (Bourouache *et al.,* 2019). A considerable reduction of electrical conductivity in treated samples was noticed and were all less than desirable limit of 300 µS/cm, which permits its discharge into receiving environment.

Among the treated samples, 15% nanosorbent adsorbed a maximum of 74.16% oily and greasy substances present in sewage water. Lowering of alkalinity levels was noticed in treated water compared to untreated sewage sample. It ensures its suitability for irrigation, as alkalinity values falls under the desirable limit of 120 mg/l. The total hardness, Ca and Mg in domestic sewage water reduced and were below its desirable limit of 300 mg/l, 75 mg/l and 30 mg/l, respectively.It could be noted that untreated sample falls under moderately hard category (60-120 mg/l) and all treated samples under soft category (<60 mg/l). The lowering of chloride concentration was noted after treatment using copper nanoparticles with rice husk ash. The observed chloride values are <250 mg/l and are within desirable limits.

Maximal increase of 40% in dissolved oxygen level was noted in treated water with 15% RHA-CuNP concentration. At levels of 5 mg/l of dissolved oxygen, the water is marginally acceptable for irrigation. As DO level of all treated water samples were above 8 mg/l, it can also be suggested for greenhouse crops (Sharma *et al.,* 2019). High BOD and COD concentration in wastewater might be due to the result of organic and inorganic pollutants indicating that the adsorbent was efficient in decreasing BOD and COD values to a maximum of 82.57 and 49.02 % at 15 % RHA-CuNP concentration. Dissolved solids accounts for major proportion of total solids as compared to suspended solids. High TDS in untreated sample implies addition of organic matter and solid waste into the sewer system. A significant removal of TDS and TSS from domestic sewage water was observed in treated water with increasing concentrations of RHA-CuNPs. As TSS values of all treated waters were almost below 1 mg/l, it reflects the efficiency of wastewater treatment by RHA-CuNPs. The recorded TDS and TSS levels were within the desirable limit of >500 mg/l, which favours its applicability for irrigation purposes. The above findings were in accordance with the findings of Ullas (2018).





It was noted that all the values of treated sewage water samples using varying concentrations of RHA-CuNPswere found within the standard desired limit as cited by BIS/ICMR/WHO except biochemical oxygen demand and chemical oxygen demand thatexceeds the standard limit of 5 mg/l and 20 mg/l, respectively. Copper nanoparticles with rice husk ash as nanosorbents were effective in wastewater treatment. Increasing the concentration of RHA-CuNPs from 5 to 15% signified affirmative results in an inclined manner and displayed pronounced impact in combating the quality of treated water. Considering nanotechnology as a double-edged sword, the safety of nanoparticles and its positive impact on environment need to be ascertained with weighing-up of risks that could pose a risk to the environment and human well-being.

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