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Green Synthesis of Magnetite Nanoparticles Using Waste Natural Materials and Its Application for Wastewater Treatment

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Abstract: In this study a simple, environment friendly and cost-effective method has been developed to synthesize metallic nanoparticles (NPs) from natural waste residues such as onion, potato, tea moringa, and discuss the effect of extract residues on efficiency, yield, size, shape and morphology of the magnetite nanoparticle. The synthesized nanoparticle was characterized by Fourier Transform Infrared spectrometer (FT-IR), X-ray diffraction (XRD), X-ray fluorescence (XRF), and energy dispersive spectroscopy (EDX). The promising applications of nanotechnology are their efficiency in wastewater treatment including removal of chemical and physical parameter. The study proposes that magnetite NPs can be synthesized using onion, potato, tea and moringa residues extract as reducing agent. The results of XRD pattern confirmed the synthesized magnetite NPs using onion, potato, tea and moringa as crystalline phase of α-Fe_2O_3. EDX spectroscopy showed the presence of elemental iron and oxygen, indicating that the nanoparticles are essentially present in oxide form. UV absorption in the range of 190–340 nm confirmed the formation of Fe/NP, and Fourier Transform Infrared spectrometer (FTIR) indicated formation of iron oxide crystalline NPs in which reducing and capping agent such as flavones, the intensity of absorption peak in FT-IR spectrum depends on type of extract. The synthesized Fe/NPs were tested for treatment of wastewater under different conditions such as contact time (0–60) min, and dose (0.1- 0.5)g, the results indicate that's magnetite NPs of moringa and onion are more effective in degradation and adsorption processes at optimum dose (0.4g, and time 45 min).

Keywords: green method; iron oxide nanoparticle; extract natural materials; scanning electron microscopic; Energy dispersive spectroscopy

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1. Introduction

Recently, there has been a great development in the use of nanotechnology in many applications such as medical and environmental fields, which has made many people believe that this technology can improve their current standard of living [1,2]. The nanoparticles are characterized by many characteristic approach such as shape and size, which allows these particles to be used in many life applications including water treatment [2].

The particles are called nano-materials at particles size are range from 1 to 100 nanometers [3]. The nanoparticles are characterized by a large surface area, which distinguishes them from the others of the bulk materials with the same composition, which made this technology have improved properties and features such as catalytic activity, electrical conductivity, hardness and antimicrobial[3]. The nanoparticles are used in water treatment due to these particles have a large functional surface area capable of binding, absorbing and carrying other compounds[2]. Among the nanoparticles that are widely used in water treatment such as iron particles with magnetic properties, these particles characterized by unique properties such as surface area, these properties of Fe/NPs make them applicable in various areas, such as catalysis, magnetic storage media, biosensors, magnetic resonance, and wastewater treatment [2,4].

The preparation of raw materials is carried out by various methods including physical, chemical, enzymatic and biological. Physical methods are divided into grinding of large particles, thermal evaporation, plasma arcing, spray pyrolysis, spray deposition, layer-by-layer growth. Chemical methods are divided into sol-gel method, electrophoresis, chemical vapor deposition, chemical solution deposition, and hydrolysis. The biological method which uses a one-step biological extraction method, which is environmentally friendly, as it uses environmentally materials such as plant materials, bacteria, fungi, microalgae, and called green synthesis method [3,5].

The green synthesis that uses plants and microorganism, the synthesis of nanoparticles is an environmentally friendly, economically viable method for large-scale production and a cost-effective method without any harmful and expensive chemicals. The green synthesis of nanoparticles are produced by the biological method in order to overcome the problems [6], which more efficiency than physical and chemical methods due to the length of time and the multiplicity of steps during the preparation process, The green synthesis method depends on the mechanism of bio-reduction of nanoparticles due to many biomolecules (vitamins, amino acids, proteins, phenolic acids and alkaloids) in plant and microorganisms. Phenolic acids are powerful antioxidants, possessing hydroxyl and carboxyl groups that are able to bind metals. The active hydrogen may be responsible for the reduction of metal ions in the formation of nanoparticles [2–4,7].

Iron nanoparticles are prepared from plant extracts such as fruit and vegetable extracts. Iron nanomaterial are considered effective materials in water treatment because of their magnetic properties. Iron particles are found in the forms of Fe_2O_3 and Fe_3O_4 [3,8,9].

Iron nanoparticles have recently gained great research interest in environmental applications since it offers high surface reactivity due to high the surface area. Environmental applications of Iron nanoparticles include detection and elimination of pollutants in wastewater treatment. The application of Iron nanoparticles in the environment offers advantages such as improved performance, lower energy consumption and reduction in residual waste. Iron nanoparticles is one of the most researched and efficient nanoparticles for the removal of pollutants from wastewater[10,11].

The prepared nanoparticles are characterized to know the extent of their formation through many methods such as scanning electron microscopy (SEM), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), visible and ultraviolet spectroscopy [3,12–14].

In this study, the preparation of iron nanoparticles (Fe/NPs) is based on the green synthesis method, where extracts of different natural materials such as moringa leaves, potato peels, tea waste, and onion peels for the synthesis of iron nanoparticles (Fe/NPs). The iron nanoparticles were characterized using different techniques such as X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), visible and ultraviolet spectroscopy (UV spectrum). The particle size, magnetic properties and morphology of Fe/NPs depend on the conditions of the materials used such as extract of onion peels, potato peels, tea waste and moringa leaves; the obtained nanoparticles have different particle sizes, morphologies, yields, and magnetic properties. These Fe/NPs were used in wastewater treatment; the different parameter is applied to determine the efficiency of iron nanoparticles such as contact time (0–60) min, and dose (0.1–0.5) g/L, using this technology after sedimentation stage of raw wastewater.

2. Materials and methods

2.1. Preparation extracts of waste natural materials and iron nanoparticles

This work aims to prepare iron nanoparticles from extracted waste natural materials (WNMs), as shown in Figure 1. The magnetic iron nanoparticles were synthesized using mixture of $FeCl_3.6H_2O$ and $FeCl_2.4H_2O$ aided with onion, potato, tea and moringa extracts. These materials were obtained from the local markets, Giza, Egypt. It were prepared by washing onion peels, potato peels, tea waste and moringa leaves several times using tap water to remove any dust, rinsed and dried at room temperature. The onion peels, potato peels and moringa leaves were cut into small pieces. Then weigh about 50 g of every wastes, then boil it in 500 ml of tap water for 30 minutes The filtrate of the extract was kept at 4 °C in the refrigerator [4,15]. The magnetite nanoparticles were prepared from the extracts by adding 5 ml of extract to a bottle of iron solution with simultaneous drop wise addition of NaOH (I N) solution (this process was carried out at 80 °C, then mixing the solution at 1000 rpm for 2 hours) [16]. The synthesis of nanoparticles is observed by changing the color solution from orange to black, the formation of Fe/NP was confirmed by the appearance of a black precipitate [15]. Fe/NPs were separated by centrifugation 1000 rpm/min, collected and dried in a dry oven at 50 °C for 48 h [11].

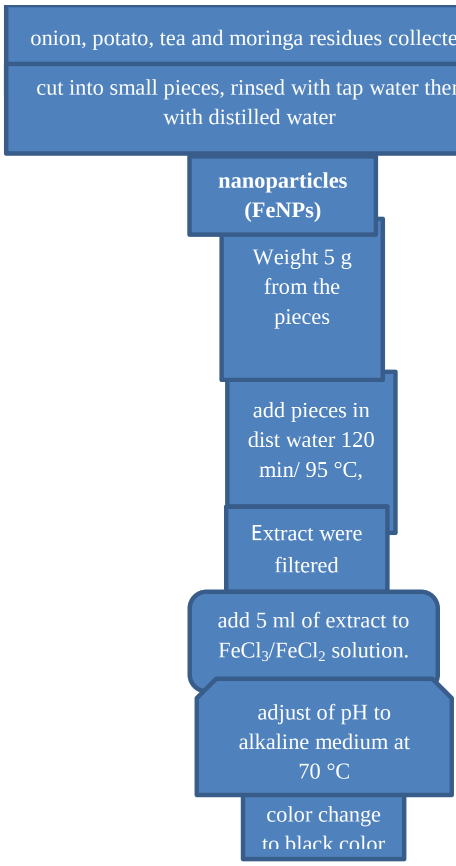


Figure 1. Schematic diagram of onion, potato, tea and moringa residues in production of iron nanoparticles.

2.2. Characterization of the synthesized Fe/NPs

The prepared magnetite nanoparticles (Fe/NPs) compounds were characterized using several instruments such as UV-Visible spectrophotometer (T-70 spectrophotometer at Housing and Building Research Center, Chemistry Lab) was used for the analysis of synthesized Fe/NPs periodically as a function of time in the wavelengths ranging from 190–340 nm with a resolution of 0.5 nm. Crystallographic study of Fe/NPs was carried out using X-ray diffraction (Shimadzu XRD 6100, Japan) with CuK α radiation from 40kV/30mA using the 2θ range of 20–70°. Chemical functional group identification on Fe/NPs was determined using FTIR (FTIR 8400S Shimadzu, Japan) in the spectral range of 400–4000 cm^{-1} and elemental analysis was done in the Na-U channel using EDX (EDX 720, Shimadzu, Japan).

2.3. Characteristics of raw waste water

2.3.1. Sample sites, and analysis of raw sample

The grey water (collected from orascolia station for wastewater treatment), characteristics indicated that such wastewater is relatively strong as exhibited by the ammonia, COD, BOD, TDS, EC, pH, PO_4, TP, TN, TKN, NH_3, NO_3, TSS, and phosphate. The characteristics of grey water are shown in Table (1) compared to the Egyptian Environmental Association Affair (EEAA) [17]. The COD and BOD were 560 and 302 mg/L, respectively. The PO_4, TP, TN, TKN, NH_3, NO_3, were 3.3, 0.66, 33.6, 28.2, 13.2, and 5.4. The pH, EC, TSS and TDS were 7.2, 1099, 330, and 611 mg/L, turbidity was 89.5 NTU. ORP was −19.7 mV, respectively.

2.3.2. Reagents

All chemicals were of analytical grade. The chemical reagents used included phosphoric acid (H_3PO_4, 85.0%, Fischer scientific UK), potassium dichromate ($K_2Cr_2O_7$, 99.0 %, Merck, Germany), boric acid (H_3BO_3, 99.5%, LOBA Chemie, India), hydrochloric acid (HCl, 37.0 %, Fischer scientific UK), nitric acid (HNO_3, 70.0%, sodium hydroxide (NaOH, 99.0 %, Merck, Germany). Ammonia solution, (NH_3, 35.0 %, Fischer scientific UK).

2.3.3. Instruments and characterization techniques

The following instruments were used through this work; furnace. The Drying oven (Fisher Scientific Equipment, American provisioner of scientific), Digital electronic balance (PCE-BSK 310 Instruments UK), and DIW system (Millipore GER) were used. The pH measurements of the samples were achieved using a pH meter (AD110, ADWA, Hungary). Fourier-transform infrared spectroscopy (FT-IR), (Thermo Fisher Scientific, UK). Orbital shakers instrument, Thermo Fisher Scientific, US). COD digestor instrument, (with auto time-controlled, MAC, India), BOD_5 incubator, (Airco, India). UV-Vis Spectrophotometers, (PG Instruments, a UK company). Incubator, (Thermo Fisher Scientific, UK). Portable multiparameter water quality measurement, (HORIBA company. the USA). Kjeldahl Digestion instrument, (ESEL, India), Samples of raw bone waste materials were analyzed by Scanning Electron Microscope (SEM) Model (Quanta 250 FEG—field emission gun—attached with accelerating voltage 30 K.V. FEI company (Netherlands) [18].

Table 1. Physicochemical characteristics of raw grey water.

Test	Unit	*Aver, Values of Raw Samples
pH	----	7.2
TDs	mg/L	611
EC	μs/cm	1099
ORP	mV	−19.7
Turbidity	NTU	89.5
COD	mg/L	560
BOD	mg/L	302
TSS	mg/L	330
NH_3	mg/L	13.2
NO_3	mg/L	5.4
TKN	mg/L	28.2

TN	mg/L	33.6
PO_4	mg/L	3.3
TP	mg/L	0.66

Notes: * Average for 3 samples, TDS is total dissolved solid, TSS is total suspended solid, COD is chemical oxygen demand, BOD is biological oxygen demand, NH_3 is ammonia, NO_3 is nitrate, TKN is total kjeldahl nitrogen, TN is total nitrogen, TP is total phosphorus, and PO_4 is phosphate., ORP is oxidation reduction potential.

2.5. Batch Experiments

The treatment wastewater experiments were carried out in 1L treated by Fe-NPs were optimized by varying the dose (0.1, 0.3, 0.4, and 0.5 g/L agitated with 3time 0 min g), and contact time (0, 15, 30, 45, and 60 min agitated with 0.4 g). All experiments were carried out in a jar test at 100 rpm. The same set of the experiment was repeated at three times. All experiments were conducted at room temperature. The residual concentration of pollutants in the filtrate was detected using the EPA method. The removal efficiency (R %), was calculated from the equation (1) [9,19,20].

$$R\% = \frac{Co-Ce}{Co} \times 100 \quad (1)$$

where R % is the removal efficiency, C_0 is the initial concentration (mg/L), C_e is concentration after adsorption (mg/L).

3. Results and Discussion

3.1. Characterization

3.1.1. UV–Vis spectral analysis of Fe/NPs

Fe/NPs formation were confirmed by the color change immediately occurred after the addition of the plant extract iron solution, and adjust pH. The dark color was a result of surface plasmon excitation vibrations in the Fe/NPs [11]. The absorption peak at 215, 210, 257, and 210 nm for onion, potato peels, tea waste and moringa respectively. indicates the presence of Fe/NPs [2]. The Figure 2 shows the UV-visible absorption spectrum of Fe/NPs synthesized using each extract waste residue. The formation of Fe/NPs is known to take place through complexation of Fe salts followed by capping of Fe with phenolic compounds [11].

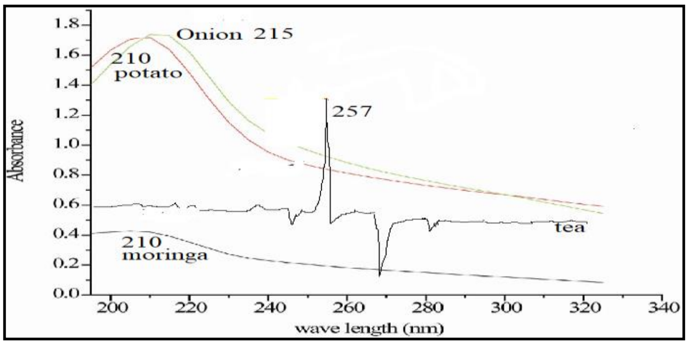


Figure 2. UV-Vis absorption spectrum of onion, potato peels, tea waste and moringa magnetite nanoparticles.

3.1.2. Appearance of synthesized Fe/NPs

The appearance of black color of Fe/NPs solution indicates the formation of Fe/NPs with the increasing time is shown in Figure 3. The color changes arise due to the excitation of the surface plasma resonance phenomenon typically of Fe/NPs [2]. The nanoparticles formation was confirmed by the color immediately converted from transparent brown to black in a few seconds demonstrating the synthesis of iron nanoparticles [11].

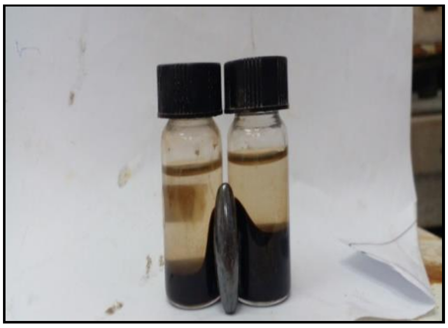
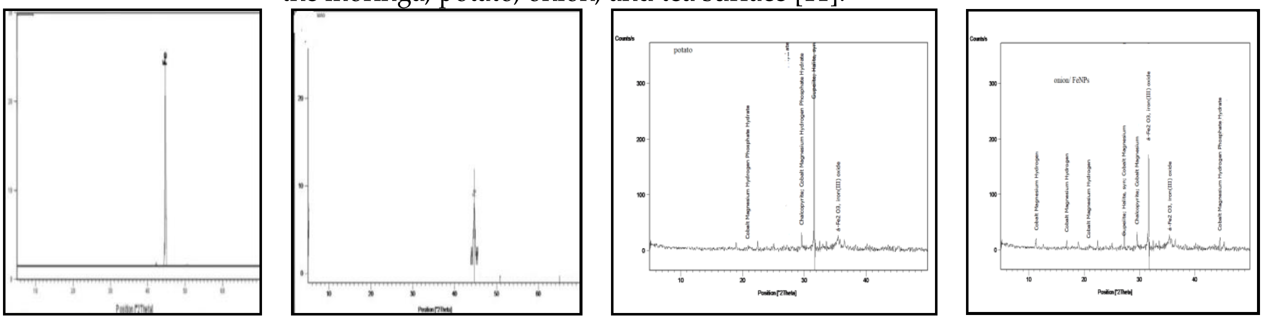


Figure 3. Images onion, potato peels, tea waste and moringa magnetite nanoparticles.

3.1.3. XRD pattern analysis of Fe/NPs

The XRD was obtained to investigate the presence of nanoparticles on moringa, potato, onion, and tea surface. The XRD pattern of the synthesized adsorbent in the angle range of 2θ, applying Cu kα radiation (λ = 1.5 A°). The XRD technique was used to identify the structure of the prepared iron nanoparticles is depicted in Figure 4.

The characteristic nanoparticle peak done around 2θ = (10°–60°). The analysis of spectrum XRD technique were used for particles size analysis of Fe/NPs, the XRD pattern, shows peaks of the nanoparticle were 44°, 35°, 35–32°and 30–35–44° for moringa, potato, onion, and tea respectively. The resulted in no clear reflection peak in potato, and onion, due to other crystalline phase, which might be present as impurity. Thus, the nanoparticles essentially consists of a binary mixture of the two spinel magnetic iron oxides, meaning magnetite-Fe_2O_3 and solids elements [1,6]. In this pattern, the peak at the angle of 32°, 30, 35, and 44° confirms the presence of Fe_2O_3.particles in the adsorbent structure. Generally, the XRD analysis confirmed that the Fe_2O_3 particles have been successfully coated on the moringa, potato, onion, and tea surface [11].

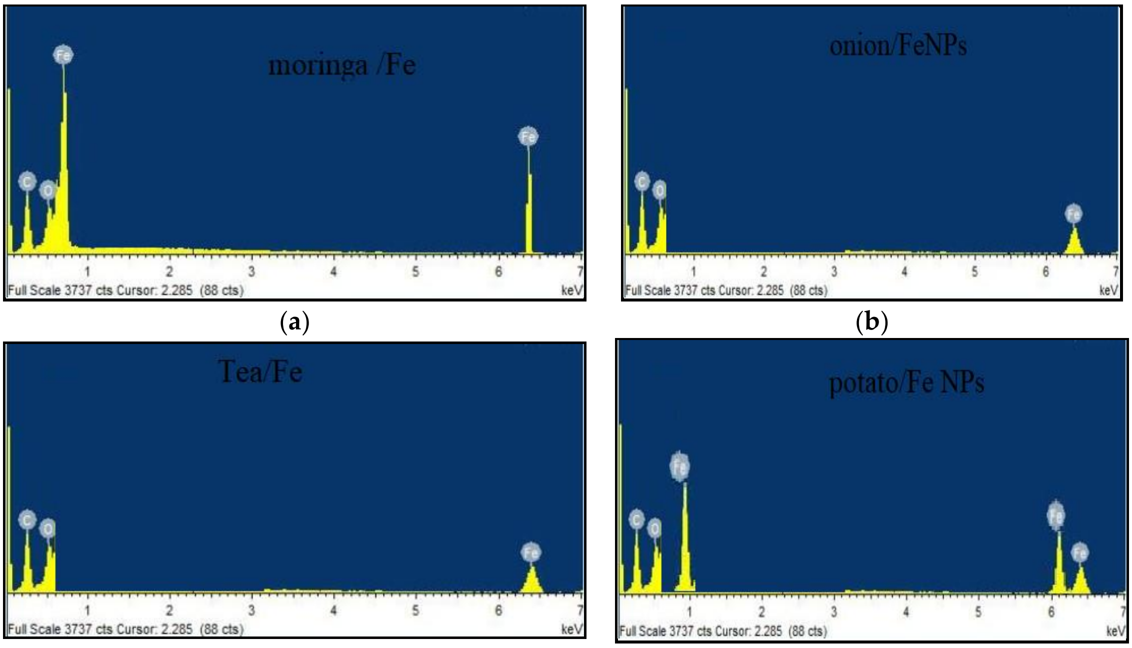


(a) (b) (c) (d)

Figure 4. XRD pattern of onion, potato peels, tea waste and moringa magnetite nanoparticles.

3.1.4. Energy Dispersive X-Ray analysis

EDX analysis was then performed on the surface of the Fe-NPs as shown in Figure 5, the EDX results of onion, potato peels, tea waste and moringa magnetite nanoparticles, which reveals the elemental composition of the prepared nanoparticles. The EDX profile shows intense peak signals of iron with a Kα peak at 6.5 keV, 6.2 keV, 0.9 keV, and 0.7 keV. Other signals observed include that of oxygen, and carbon, the presence of C and O peaks are related to polyphenols or any other C and O containing a compound in natural materials extract. The existence of elemental iron and oxygen demonstrating that the nanoparticles are essentially present in oxide form [11]. The percent of detected elements were carbon (C) 12 %, iron (Fe) 52 %, and oxygen (O) 28%. These results indicate the extract of moriga leaves and potato peels were highly efficiency than onion, and tea for formation magnetite iron nanoparticles. Very similar results were reported for Fe nanoparticles prepared with other leaf [11].



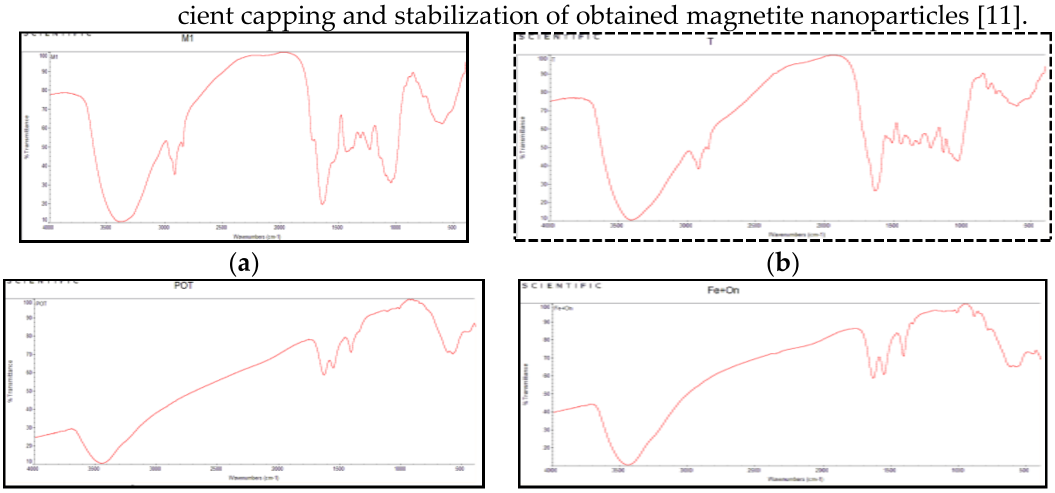
(**a**) (**b**)

(**c**) (**d**)

Figure 5. The EDX pattern of onion, potato peels, tea waste and moringa magnetite nanoparticles.

3.1.5. The FTIR spectra of Fe-NPs

The FTIR measurements were carried out to identify the possible bio-molecules responsible for the reduction of ferrous chloride and capping of the reduced Fe-NPs. The FTIR spectra of Fe-NPs after preparation by green synthesis method from extract onion, potato peels, tea waste and moringa are shown in Figure 6. All of the above peaks can be detected in the spectrum of synthesized Fe-NPs were subjected to FT-IR that showed various bands, the O-H stretching around 3400 cm^{-1} show the presence of hydroxyl groups from the polyols such as flavones, terpenoids and polysaccharides present in the various extract. The decrease in intensity of band O-H stretching in onion, and potato might be due to interaction of nanoparticles. The bands at 1645 cm^{-1} and 1041cm^{-1} denotes the presence of organic material in the sample majorly contributed by onion, potato peels, tea waste and moringa iron magnetite particles (Fe-NPs). These bands confirmed the presence of compounds like flavonoids and terpenoids and hence may be held responsible for efficient capping and stabilization of obtained magnetite nanoparticles [11].



(**a**) (**b**)

(**c**) (**d**)

Figure 6. FTIR spectrum of onion, potato peels, tea waste and moringa magnetite nanoparticles.

3.1.5. XRF analysis of banana, orange, and pomegranate

The XRF pattern of Iron oxide nanoparticle prepare from onion, potato peels, tea waste and moringa as shown in Table (2). The results had shown the Fe_2O_3 composite in onion, potato peels, tea waste and moringa Fe-NPs. The percent of magnetite nanoparticles (Fe_2O_3) from onion, potato peels, tea waste and moringa are 67.3%, 53.92%, 40.86%, and 46.86 %, respectively. The Fe_2O_3 percent in magnetite nanoparticles is onion > potato peels > moringa > tea waste.

Table 2. The XRF of onion, potato peels, tea waste and moringa magnetite nanoparticles.

Sample Name	Fe_2O_3	Na_2O	MnO	CaO	SiO_2	Al_2O_3	K_2O	SO_3^{--}	Cr_2O_3	MgO	Cl^-	LOI	Total
Fe-Tea	40.86	19.8	0.33	0.47	0.38	0.11	0.03	0.13	0.01	0.07	15.6	22.2	99.99
Fe-Potato	53.92	16.1	0.53	0.3	0.37	0.09	0.05	0.09	0.05	0.04	9.63	18.8	99.98
Fe-Onion	67.3	8.39	0.63	0.47	0.38	0.08	0.14	0.05	0.05	0.04	11.6	9.51	99.94
Fe-Moringa	46.62	22.1	0.46	0.27	0.36	0.07	0.07	----	----	0.04	14.9	15.1	99.99

3.1.6. Yield of iron oxide nanoparticles

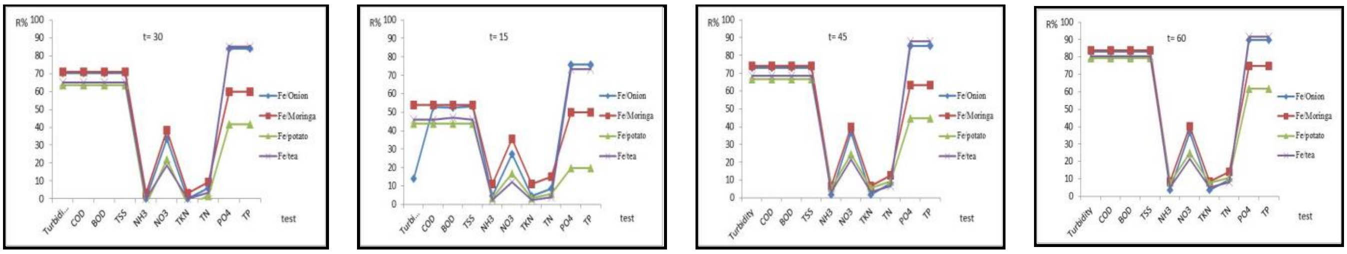
The iron oxide nanoparticles dry at 50 ^{0}C until the magnetite nanoparticles completed dry. The weight of magnetite nanoparticles related to type of extract used in synthesis of nanoparticles. Table (3) shows weight of magnetite nanoparticles for moringa, potato, onion and tea are 38.235, 19.116, 19.116, and 12.899 respectively.

Table 3. yield of onion, potato peels, tea waste and moringa magnetite nanoparticles.

Iron Oxide Nanoparticle	Weight (g)
Fe-metal	7.625
Fe-Moringa	38.235
Fe-Potato	19.116
Fe-Onion	16.114
Fe-Tea	12.899

3.2. Effect of contact time

Figure 7, illustrates the effect of contact time on the efficiency of magnetite nanoparticles for removal of pollutants from grey wastewater, the following condition: 0.1 g/l solution of the adsorbent, optimal pH (pH = 7.5 ± 0.1) and the contact time of (0–60) min, as indicated in Table 4, the removal efficiencies were increased sharply up to equilibrium at 45 min and then it slightly increases after 45 min until 60 min. The sharp increase in the removal efficiency may be due to the existence of enormous vacant active sites in the surface. However, by raising the contact time the availability of pollutants to the active sites on the adsorbent surface is limited [21], which makes the adsorption efficiency reduce. In a similar study, this phenomenon was investigated using different adsorbents [1]. Iron nanoparticles are used for removing pollutants from wastewater, due to the interaction between the compounds and the functional groups at the surface of absorbent. The functional groups serve to define the effectiveness, selectivity, capacity, and reusability of an absorbent. Furthermore, in the case of high iron oxide loading at the surface, the higher rate of reduction in nitrate, and ammonium ion [22]. The result showed that the optimum time for metals removal by magnetic nanoparticles was obtained in 45 min [1,23].



(**a**) (**b**) (**c**) (**d**)

Figure 7. Effect of contact time on efficiency of iron magnetite nanoparticles at (agitation speed 200 rpm, dose 0.1 g/L and 20 ± 5°C).

Table 4. The residual concentration of pollutants and removal efficiency of all adsorbents at optimum time.

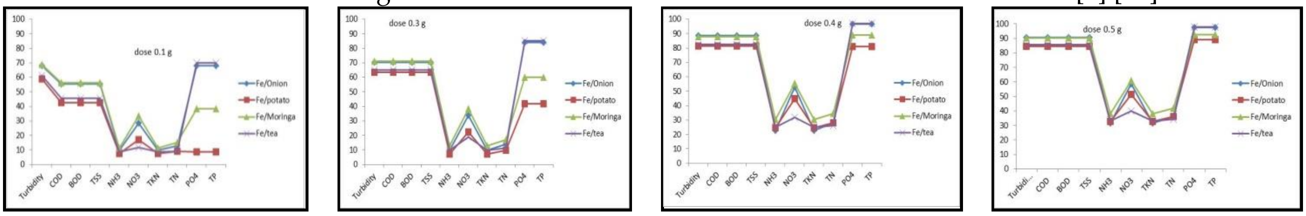
Parameter	Unit	Raw	Residual Concentration (mg/L) of Pollutants at Optimum Contact Time 45 min—Turbidity as NTU				Removal Efficiency of Adsorbents (%)			
			Fe/onion	Fe/moringa	Fe/potato	Fe/tea	Fe/onion	Fe/moringa	Fe/potato	Fe/tea
pH	----	7.2	8.3	8.19	8.6	8.4	----	----	----	----
TDS	mg/L	611	688	745	752	978	----	----	----	----
EC	µs/cm	1099.8	1238.4	1341	1353.6	1760.4	----	----	----	----
ORP	mV	−19.7	−80	−72	−95	−83	----	----	----	----
Turbidity	NTU	89.5	24.31	23.19	29.75	28.15	72.85	74.10	66.78	68.57
COD	mg/L	560	152	145	186	176	72.85	74.10	66.78	68.57
BOD	mg/L	302	82.08	78.3	100.44	95.04	72.85	74.10	66.78	68.57
TSS	mg/L	330	89.68	85.55	109.74	103.84	72.85	74.10	66.78	68.57
NH_3	mg/L	13.2	12.98	12.34	12.45	12.79	1.66	6.51	5.68	3.10
NO_3	mg/L	6.4	4.05	3.85	4.82	5.03	36.71	39.84	24.68	21.40
TKN	mg/L	28.24	27.7	26.4	26.6	27.3	1.66	6.51	5.68	3.10
TN	mg/L	34.64	31.8	30.2	31.4	32.4	8.14	12.67	9.19	6.48
PO_4	mg/L	3.3	0.489	1.205	1.8	0.398	85.18	63.48	44.57	87.93
TP	mg/L	0.66	0.097	0.241	0.36	0.079	85.18	63.48	44.57	87.93

Notes: TDS is Total dissolved solid, TSS is Total susbended solid, COD is Chemical oxygen demand, BOD is Biological oxygen demand, NH_3 is Ammonia, NO_3 is Nitrate, TKN is Total kjeldahl nitrogen, TN is Total nitrogen, TP is Total phosphorus, and PO_4 is phosphate.

3.5. Effect of Adsorbent Dosage

The effect of amount (0.1–0.5g/L) magnetic nanoparticles (Fe/NPs) on removal of pollutants from wastewater such as chemical oxygen demand, biological oxygen demand, total suspended solid, turbidity, Ammonia, kjeldahl nitrogen total nitrogen, Phosphate, and nitrate, were studied in samples before and after treatment. The dosage of nanoparticles affects its ability to sorbent contaminants. As shown in Figure 8, when the magnetic particles dosage increased, the removal efficiency increased, as shown in Table (5). Usually, the reduction of pollutants concentration with increased dose of iron nanoparticles is a surface function. This may be assumed that the availability of active sites on the nanocomposite is increase at higher doses [8] [23].

The effect of different amounts of Fe/Nps on the adsorption capacity and efficiency under the optimal condition (pH = 7.4, t = 45 min and 200 rpm) is illustrated in Figure 9. It can be observed that with an increase in the adsorbent dosage from 0.1 to 0.5 g/l the removal efficiencies at optimum dose (0.4), for onion, potato, moringa and tea, were from 88.39, 88.39, 88.39, 88.39, 22.86, 52,81, 22.86, 27,94 and 96.66%, 81.25, 81.25, 81.25, 81.25, 24.57, 44.68, 27.98, and 81.06 %, 87.85, 87.85, 87.85, 87.85, 30.17, 55.46, 34.45, and 88.93 %, 82.5, 82.5, 82.5, 82.5, 24.91, 31.87, 26, 09, and 97.06 % of COD, BOD. TSS, turbidity, Ammonia, TKN, TN, Phosphate, and nitrate respectively. The rise in the adsorption efficiency is related to the increase in the availability of active sites on the adsorbents which can give rise to the adsorption of pollutants. Jung et al. reported that with an increase in the dosage of various adsorbents, the pollutants removal was enhanced. However, a decrease in the adsorption capacity with an increase in the adsorbent dosage is probably due to instauration of the active sites on the adsorbent surface during the adsorption process. This phenomenon can also be due to the aggregation resulting from high adsorbate concentrations, leading to the decrease in the active surface area of the adsorbent [1] [23].



(**a**) (**b**) (**c**) (**d**)

Figure 8. Effect of different doses on efficiency of iron magnetite nanoparticles (agitation speed200 rpm, time 45 min and 20 ± 5°C.

Table 5. The residual concentration of pollutants, and removal efficiency of all adsorbents at optimum dose 0.4.

parameter	Raw	Residual concentration (mg/L) of pollutants at optimum dose 0.4—turbidity as NTU				Removal efficiency of adsorbents (%)			
		Fe/onion	Fe/potato	Fe/moringa	Fe/tea	Fe/onion	Fe/potato	Fe/moringa	Fe/tea
pH	7.2	8.35	8.6	8.25	8.52	----	----	----	----
TDS	611	703	750	752	1005	----	----	----	----
EC	1099	1265	1350	1353	1809	----	----	----	----
ORP	−19.7	−85	−105	−75	−89	----	----	----	----
Turbidity	89.5	10	16	10.	15	88.39	81.25	87.85	82.5
COD	560	65	105	68	98	88.39	81.25	87.85	82.5
BOD	302	35	56	36	52	88.39	81.25	87.85	82.5
TSS	330	38	61	40	57	88.39	81.25	87.85	82.5
NH_3	14.6	11.3	11.05	10.2	11	22.86	24.57	30.17	24.91
NO_3	6.4	3.02	3.54	2.85	4.3	52.81	44.68	55.46	31.87
TKN	31.3	24.1	23.6	21.8	23.5	22.86	24.57	30.17	24.91
TN	37.7	27.2	27.1	24.7	27.9	27.94	27.98	34.45	26.09
PO_4	3.3	0.11	0.62	0.36	0.097	96.66	81.06	88.93	97.06
TP	0.66	0.022	0.125	0.073	0.0194	96.66	81.06	88.93	97.06

Notes: TDS is Total dissolved solid, TSS is Total susbended solid, COD is Chemical oxygen demand, BOD is Biological oxygen demand, NH_3 is Ammonia, NO_3 is Nitrate, TKN is Total kjeldahl nitrogen, TN is Total nitrogen, TP is Total phosphorus, and PO_4 is phosphate.

4. Conclusions

In the present study, the synthesized iron nano particles aided with natural waste material such as onion, moringa, tea waste, and potato that's used as reduction, stabilization agent for the synthesis of iron nanoparticles, and used as an adsorbent for the treatment wastewater. The synthesized of iron nanoparticles were confirmed by different characterization techniques such as EDX, XRF, FT-IR, XRD, and UV spectrum. The XRF, and XRD pattern of the iron nanoparticles revealed a crystalline structure of the nanoparticles. The results illustrated that the synthesized adsorbent showed iron magnetite aided with moringa and onion are a high efficiency than magnetite aided with potato, and tea. The optimum conditions for the adsorption process obtained, the contact time of 45 min and the dose 0.4 g. Moreover, Due to favorable performance of onion, and moringa in the removal of pollutants and its feasible separation from the aqueous solutions, it can be used as an efficient adsorbent in the treatment of water and wastewater, after conducting the necessary tests for the out lest samples of water after treatment process, it was found that there were no negative effects on the water samples.

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