Open Access Research Journal of
Biology and Pharmacy
Journals home page: https://oarjbp.com/
ISSN: 2782-9979 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(REVIEW ARTICLE)

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Investigations on the Iraqi marshlands aquatic plants extracts as reductants and capping agents for nanoparticles synthesis

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Open Access Research Journal of Biology and Pharmacy, 2022, 06(01), 001–016

Publication history: Received on 03 August 2022; revised on 09 September 2022; accepted on 11 September 2022

Article DOI: https://doi.org/10.53022/oarjbp.2022.6.1.0062

Abstract

The marsh lands aquatic plant are thoroughly reported to contain various types of phytochemicals including polyphenolic compounds like flavonoids and tannins, alkaloids and glycosides, terpens, sugars, polysaccharides, vitamins, and proteins that are mostly exhibit antioxidant activity due to their structural reducing functionalities. Thus, their extracts are extensively reported to be used as reducing and/or capping agents for eco-friendly bio-synthesis of various elements nanoparticles of multiple biological influences. This survey is conducted to explore the utilization of aqueous and other extracts of aquatic plants detected in the marshlands southern of Iraq including *Typha*, *Ranunculus*, *Potamogeton*, *Nymphaea*, *Nasturtium*, *Mentha* species, *Ceratophyllum demersum*, *Ranunculus laetus* and *Bacopa monnieri*, besides, the biological activities of the synthesized nanoparticles.

Keywords: Iraqi marshlands; Aquatic plants; Reductants; Capping; Nanoparticles; Synthesis

1. Introduction

Metals and metal oxides nanoparticles are nowadays as impressively promising antibacterial and bacterial resistance counteracting agents design approach. In this context, it is reported that nanoparticles of metals like gold, silver, palladium, platinum, copper, zinc, and iron and of metal oxides exhibit antimicrobial influences particularly against both gram positive as well as gram negative bacterial strains including the resistant strains [1, 2] probably via essential respiratory chain bacterial enzymes inhibition, cell wall/membrane damage through Fenton reaction mediated oxidative stress generating reactive oxygen species besides blocking fundamentally essential micronutrients uptake, electrostatic interaction with the cell membrane and inhibition of ATP-protein synthesis and lipid peroxidation [1, 3-4]. Reactive oxygen species like singlet oxygen, hydroxyl radical, H_2O_2, superoxide anion, and other reactive species are accumulated by the action of these nanoparticles that will target the internal cellular proteins and DNA [1, 4-5]. Various types/shapes nanoparticulates of different metals have reductively synthesized to exhibit an antibacterial activity such as silver nano-spheres, nano-plates, and nano-rods [6-10] due to their chemical stability, electrical conductivity and antimicrobial activity [11-14]. Similarly, gold/hydroxypropyl cellulose (HPC) hybrid and ZnO/Ag hybride nanocompsoites also exhibit antimicrobial activity [15, 16]. Zinc oxide nanoparticulates exhibit antimicrobial, antioxidant, anticancer and neuroprotective influences besides a potential use in gene therapy [17, 18].

Recently, metal oxides nanoparticles like zinc oxide, titanium oxide, magnesium oxide and silicon oxide have wide medicinal applications including disease therapy, diagnosis and surgical procedures as they have elective toxicities to biological system as in case of antimicrobial [19] and anticancer activities. Diverse methods are used to prepare nanoparticles including physical, chemical and biological methods, however, the first two methods requires the use of elevated temperature, pressure and current in addition to the used of poisonous materials such as arsenic, sodium

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borohydride, hydrazine..etc [20]. In addition, various sub methods are used in these three classes of methods such as sol–gel, micro-emulsion, hydrothermal, sonochemical, chemical reduction and green synthesis, yet, for some times more than one method is used for the preparation of platinum nanoparticles [21]. These methods are used to prepare different sizes and shapes nanoparticulates such as photochromic, core−shell, polymer-coated magnetite, and metal oxide nanoparticles. The synthesized nanoparticles synthesized via these classes of methods include zinc, iron, magnesium, silver, cesium and zirconium oxides [22-25]. It is necessary to note that small size nanoparticules tend to aggregate at low pH in larger sizes [26].

In general, the process of using plant extract for bio-reduction mediated nanoparticles production involves simple mixing of the aqueous extract with aqueous metal source compound solution in certain reaction conditions. The synthesis reaction some time simply happens at room temperature and even completes within minutes which is mostly indicated by color change of the reaction solution as in case of titanium oxide eco-friendly synthesis using *Cassia auriculata* leaves extract and *Planomicrobium* specie [27, 28]. However, the process of bio-reduction is actually complex one because of the multiply various phytochemicals involved in the reduction process [29] however, the processes of nano-particles synthesis is enhanced using ultrasound activation particularly when using plant materials [30]. For example, fast and easy bio-synthesis of silver nanoparticles from silver ion is preformed at room temperature using *Nasturtium officinale* aqueous leaves extract [31, 32] where the particle size, shape as well as their antibacterial influences are greatly dependent on the concentration and the type of the reducing phytochemicals [33]. In other nanoparticle synthesis example, zinc oxide nanoparticles of multiple medicinal uses are biosynthesized using broad spectrum of plant extracts containing various types of phytochemicals as reducing, chelating, or capping agents [34]. Interestingly, although it is an expensive approach genetic materials like DNA can be used for the biosynthesis of nanoparticles [35]. A huge number of studies have been reported for the eco-friendly bio-synthesis of metal particulates processing various biological activities such as gold, silver, copper, platinum, nickel, magnesium, iron and zinc oxide nanoparticles [36-39]. Nanofilm and nanoparticles of metal oxides are multiply reported to be greenly synthesized using plant extracts rather than chemical methods of several disadvantages [40]. Finally, several factors determines the nanopartilces toxicity including, the nanoparticle morphology, its synthesis method, it concentration, the type of plant used/its extract phytochemicals concentration and type of the affected cells as well as their exposure time [41] as reported for titanium oxide toxicity through its effect on the fibroblast cell viability at 600 μg/ml rather than lower concentration that declined by 37% after 48hr exposure rather 21% after 24hrs of exposure [42].

2. Marsh lands aquatic plants extracts as a reducing and/or capping agents for nanoparticles bio-synthesis

The marsh lands aquatic plant are thoroughly reported to contain various types of phytochemicals including polyphenolic compounds like flavonoids and tannins, alkaloids and glycosides, terpens, sugars, polysaccharides, vitamins, and proteins that are mostly exhibit antioxidant activity due to their structural reducing functionalities. Aquatic plants such as coontail for example are reported to have several phytochemicals involved in the synthesis of silver nanoparticles as reducing as well as capping agents [43]. For example, *Mentha aquatica* extracts are rich with flavonoids and other phenolic compounds as it has been reported to contain total phenolic content of 337 ± 2.15 while flavanoid content 15.75 ± 0.25 mg/g [44]. Thus, their extracts are extensively reported to be used as reducing and/or capping agents for eco-friendly bio-synthesis of various elements nanoparticles of multiple biological influences. They have gained increasing interest in Iraq [45, 46].

2.1. *Typha* specie

The ethanolic extract of of *Typha latifolia. L* leaves at concentration of 25% (w/v) is uaed for green synthesis of zinc oxide nanoparticles from zinc chloride in an alkaline conditions in shape of nanoflowersn in a single step. These nanoparticles of catalytic properties that degrades indigo carmine dye upto 83% within hours [47]. Similarly, the *Typha angustifolia* leaves aqueous extract is used in the ecofriendly bio-synthesis of silver nanoparticles from silver nitrate at ambient temperature within 15 minutes that are of uniform size range, spherical shape, and with size range of 3-18 nm while, avarge size of 8 nm. It is proposed thast the phytochemical contents like alkaloids, tannins, steroids, phenols, saponins, and flavonoids probably involved in the biosynthesis of these amorphous crytaline silver nanoparticles through acting as reducing agents indicated by the FTIR spectra straching bands of phenolic OH and C=O groups. In addition, the authors emphasizes the posiiblity of terpens involvement in the bio-reduction of silver nitrate despite their lipophilicity while proteins may act as capping agent through interaction with the silver cation without any alteration in its secondary structure through their free amine groups or cysteine SH free group as what happens with gold nanoparticles. The nanoparticle composition analysis have revealed that 94% of the nanoparticle surface is the metallic silver while silver cation in its first and second oxidation states was 5% and 1% respectively. The very small size silver nanoparticles may explains its efficient antigram negative bacteria investigated against *Escherichia coli* and *Klebsiella* *pneumoniae* in synergism to commercially available antimicrobial drugs, gentamicin, cefotaxime, and meropenem at concentrations of 10 μg/mL, 30 μg/mL, and 10 μg/mL respectively. These bio-synthesized silver nanoparticles have exhibited dose-dependent antimicrobial influence against these investigated bacteria alone or in combination with various broad-spectrum commercial antimicrobial agents at sub-bactericidal concentration of them via promoting reactive oxygen species generation as well as prohibiting cellular viability explaining their syergesitic influence suggesting their use as an adjuvant therapy to infectious disease. These silver nanoparticles may attach to the bacterial cell membrane via the nanoparticles effective surface hence, disturbing the cell membrane permeability/function and respiration. Gurunathan S, 2015have reported that these silver nanoparticles have exhibited potent bactericidal activity against *E. coli* and *K. pneumoniae* at MICs (1.4 μg/mL) and attributed their antimicrobial influence to the smaller size, surface area and surface functionalization with the plant phytochemicals explaining their rapid cellular uptake. Remarkably, meropnem has exhibited the highest enhancement of bacteridal activity (75%) in synergism with silver nanoparticles followed by cefotaxime (63%) and gentamicin (48%) [48].

2.2. *Ranunculus laetus* and *Ceratophyllum demersum*

Khalid, *et al*., 2019 have reported the use of the *Ranunculus laetus* 90% leaves aqeous extracts for the ecofriendly bio-synthesis of silver nanoparticles of face-centered cubic lattice nanocrystals, of spherical shape and polydisperesed nature with 17.65 and 39.79 nm size range and an average size of 24.125 nm from 0.1 M silver nitrate in mixing ratio of 1:9 at room temperature. However, the scanning electron microscopic image has revealed that the synthesized the nanoparticles are 7.21–17.62 nm in diameter. The plant extract phytochemicals serves as reducing as well as capping agent particularly nitro and aromatic amines compounds that stabilizes these nanoparticles. Their antimicrobial activity against the gram negative bacteria *Escherichia coli* (MTCC No. 739), *Pseudomonas aeruginosa* (MTCC No. 1688), besides the gram positive bacteria *Staphylococcus aureus* (MTCC No. 96), and *Bacillus subtilis* (MTCC No. 441) is investigated at concentrations 25mg/ml, 50 mg/ml and 100 mg/ml using 100 mg/ml Streptomycin as positive standard. These nanoparticles have exhibited a dose dependent antimicrobial influence against the three bacterial species while, their activity is in following order *P. aeruginosa*>*S. aureus* > *E. coli*>*B. subtilis* according to zone of inhibition on one hand. On the other hand, these silver nanoparticles have exploited bactericidal influence against *P. aeruginosa* and *E. coli* at MIC concentration of 1×10^{-1} while against *S. aureus* and *B. subtilis* at 10 mg/ml thus the authours have spectulate that they have enhanced antimicrobial influence against the tested pathogenic bacteria [49].

Furthermore, (Abdulqahar *et al*, 2021) have reported the use of aqueous coontail (*Ceratophyllum demersum)* extract using silver nanoparticles from 0.1 M of crystalline 10 nm average size within 15 minutes under sunlight exclusive as no reaction occurs at dark at room temperature as well as boiling method. These silver nanoparticles are investigated for their antimicrobial activity against *Escherichia coli* and *Staphylococcus aureus* and was found to be effective only against *E. coli* which is silver ion releasing capsity dependent that is based on nanoparticles concentration, aggregation, shape and size besides environment pH and temperature besides, the phytochemicals related nanoparticles capping and stabilization. Nevertheless, they have attributed the effectivness against the gram negative bacteria species, *E. coli* to the synthesized nanoparticles bacterial membrane attachment as well as penetration [50].

2.3. *Mentha* specie

Investigators have reported the utilization of *Mentha* specie extracts for the bio-synthesis of biologically effective nanaoparticles. In this context, (Fathi, *et al*, 2017) have reported the use of *Mentha aquatic L* leaves and aerial parts extracts for the bio-synthesis of spherical shape silver nanoparticles of mean size of 30 nm from silver nitrate at pH = 11 as green and eco-friendly reducing agent [51]. Whereas, (Nouri *et al*., 2020) have reported the eco-friendly bio-synthesis of extensively small size silver nanoparticles using the leaves extract of *Mentha aquatic* in reducing and capping process from silver nitrate when mixed in a ratio of 1:1 under both hydrothermal as well as ultrasound (200 W at room temperature 10 minutes) reaction methods within under an alkaline conditions best at pH range of 9-9.5. They have demonstrated that the nanoparticles resulted from ultrasonic method are of average size of 8 nm diameter while that synthesized using hydrothermal method are of 14 nm diameter. The ultrasound synthesized silver nanoparticles are revealed to be of catalytic properties besides being of antimicrobial influence. They have emphasized that the phenolic phytochemicals acts as reducing agents that gets oxidized to quinone while providing electrons for the reduction of the silver cation to an elemental silver to form the silver nuclei that upon further reduction results in the nanoparticles generation. The FTIR of the synthesized nanoparticles have demonstrated that phytochemicals like flavonoids, steroids, saponins, tannins, alkaloids, phenolic, sugar, saccharides, and proteins in the plant aqueous extract are contributers to their bio-synthesis as reducing and/or capping agent. However, the reaction temperature and pH also have role in the reduction of the silver nanoparticles. Remarkably, the smaller size ultrasound produced nanoparticles have significantly much potent antibacterial activity against the tested bacteria as compared to the larger size hydrothermal method produced one as the MIC value of the ultrasound produced silver nanoparticles against *P. aeruginosa*, *E. coli*, *B. cereus,* and *S. aureus* were 2.2, 58, 20 and 198 μg/mL respectively while that of the hydrothermally produced ones are 2.6, 64, 25, 256 μg/mL respectively. Thus, the ultrasound mediated silver nanoparticles have exhibited potent bactericidal influence against *P. aeruginosa* at MIC of 2.2 μg/mL [52]. Recently, (Bathula, *et al*., 2021) have reported the utilizatiuon of *Mentha aquatica* leaves extract for the ultrasound mediated titanium oxide 18-20 nm average size spherical nanoparticles from Titanium tetra butoxide within 15 minutes at room temperature that are further functionalized with carbon to produce cost-effective green photocatalyst [53]. However, earlier (Koca, and Duman, 2019) have reported the utilization of the ethanolic *Mentha aquatic* leaves extract for the bio-synthesis of 69 avarage size titanium oxide spherical nanoparticles with anatase form of a tetragonal structure form Ti(IV) isopropoxide at acidic pH of 4.5. They have emphasize that the plant phytochemical pocess the functional groups involved in the reduction, covering their surface, and maintain the acidity of the medium as well as capping of nanoparticles as the plant extract is rich with flavonoid and other phenolic compounds. Interestingly the synthesized silver nanoparticles have exploited concentration and time dependent cytotoxic influence at 50 and 100 µg/ml concentration against marrow-based mesenchymal stem cells in rats model is plasmid DNA breaking influence. The effective titanium oxide nanoparticle size was 304 nm as it damages the plasmid pBR322 DNA hence declines these cells viability which have been more effective than their smaller nanoparticles. These silver nanoparticles have exhibited a decline in the cell viability without any circular shape DNA structure viability at concentration > 500 µg/ml leading to linear form III structure, however, the plasmid form II structure at 250 µg/ml concentration [41].

2.4. *Potamogeton* specie

In this aspect, (Shabnam, 2013) have reported the utilization of phenolics, sugars, amino acids, proteins and other phytochemical free green Thylakoids/chloroplasts containing aqueous extract of *Potamogeton nodosus* in the bio-synthesis of mostly spherical, cyrstaline nature 5–20 nm average size gold nanoparticles at phosphate buffer pH =7.2 under the sun light in a photosynthetic method at ambient conditions. they reported that UV-light while photosynthesis has driven the reduction of goldium ion Au^{+3} to the elemental gold that nucleate to the nanoparticles via transfer of electrons donated by the ions by thylakoids/chloroplasts components of the extract, yet, no photosynthesis has been reported at dark conditions. Thus, they concluded that the plant thylakoids/chloroplasts of *P. nodosus* have exploited enourmace capability to reduce goldium cation through the transfer of electrons from water molecules making use of sun light activation energy and can be used for large scale nanoparticles production [54]. Erlierly, (Abdel Hamid, *et al*., 2013) have reported the utilization of sago pondweed (*Potamogeton pectinatus* L.) aqueous extract for the synthesis of mostly spherical gold, silver, and gold-silver biocomposate nanoparticles from $HAuCl_4.H_2O$, silver nitrate and their 1:1 molar ratio alloy-type gold-silver mixture at pH =12 via heating for 15 minutes, 30 minutes, 30 minutes respectively with overall physicochemical stability of 3 weeks. The FTIR results have demonstrated that the flavons and proteins present in the plant aqueous extract are involved in the bio-synthesis as well as stabilization of the 8.4 $\pm$3 nm average size spherical shape well capped gold nanoparticles. However, the silver nanoparticles are polydisperse with an average size of 50.4 $\pm$21.8 nm. Nevertheless, the gold nanoparticles bio-synthesis is dependent on the $HAuCl_4.H_2O$ concentration where the greatest yield is obtained at 10^{-3}M while at 10^{-2} M concentration precipitation occurs, yet, at 10^{-2} M the alloy-type gold-silver nanoparticles failed to be synthesized due to the precipitation of AgCl just upon mixing of their two salts. However, as the temperature inclines the yield of nanoparticle production increases, yet, silver nanoparticles not generated at 70 C^0 while enhanced at 90 C^0. In addition, they reported that at acidic pH (3.5) is the optimum one for silver nanoparticles production however, at extremely alkaline pH of 12 nucleation as well as particles growing happens due to the activation of plant phytochemicals involved in the bio-synthesis as what occurs in alloy-type gold-silver bimetallic nanoparticles. They also postulated that the alloy-type gold-silver bimetallic nanoparticles is produced due to the miscibility of the closely resemble lattice structure in a homogenous alloy. Remarkably, the alloy-type gold-silver bimetallic nanoparticles shape and size is pH dependent where at pH 12 they exhibit mostly spherical average size of 6.6$\pm$ 2.4 nm are obtained, while, at pH=4 a multiple-twinned octahedral shape 10.6 $\pm$5.0 nm average size nanoparticles are obtained. The smaller and more uniformely size nanoparticles obtained at pH=12 is due to the higher reduction rate. The authors has also reported that these nanoparticles are coated with the plant phytochemicals protective layer preventing their aggregation. FITR results indicated the existence of O-H, COOH, C=C, C-H, C-N and amide C=O as well as N-H functionalities stretching vibrations indicating the existence of polyphenolic compounds like flavonoids besides proteins involved in their bio-synthesis and capping. The authors have suggested that luteolin flavone abundant in the plant aqueous extract are responsible for the reduction of these metal ions besides, the involvement of the protein carboxylic and amino residues in their reduction. In addition the role of the protein carboxylate, amine and carbonyl functionalities in the protein interaction with the nanoparticle surface, thereby, stabilizing them to prevent their aggregation, hence, the bio-synthesis process free of toxic surfactants as well as reducing agent [55]. Lateron, (Sedki, *et al*., 2015) have reported the utilization of *Potamogeton pectinatus* aqueous extract for the synthesis of spherical two small 11-20 nm size range (66%) and 21-30 nm size range (24%) nanocompsite (nanosheets) of silver-Reduced Graphene Oxide (Ag-RGO) or nanosheets under ultrasonication condition within 4 hours intervals. The FTIR results have demonstrated the existence of amine, olephenic C=C, nitrile C≡N, as well as many oxygen functionalities such as hydroxyl and carbonyl functionalities starching of polyphenolic compounds, proteins, carbohydrates indicating the extract phytochemicals roles as reducing and capping agents that donates electron to the silver cation. However, the long chain carbohydrates as well as proteins acts as capping agents. In addition, the temperature has strong influence as accelerator is also recorded as the reduction process is accelerated at elevated temperature, yet, at temperatures > 90 C^0 the reducing phytochemicals undergoes catalytic degradation. These oxygen functionalities interacts with the nanoparticle surface, hence, inclines the intemingeling spacing between the graphite sheets without complete separation. The synthesis of these of silver-Reduced Graphene oxide nanosheets involves two steps, the first invole physical binding of the silver cation onto the graphene oxide nanosheets while the second step involve the reduction of these silver ions into silver nanoparticles by the plant extract phytochemicals, thus the interaction between the silver nanoparticles and the grapheme oxide nanosheet happens in a manner resembles that of metal-metal fusion. These nanoparticles have potent antimicrobial influence against *E. coli* bacteria which is concentration and time dependent which approaches 92±4.1% after 4 hours incubation. The authors have reported that two mechanisms is related to the sharp edges of GO nanosheets physical stress imposed on the cell wall while, the second one is via oxidative stress induced damage to the critically vital organelles and components particularly sulfahydrile containing proteins, interaction with the DNA phosphate moieties and membrane structural/functional proteins [56].

2.5. *Saliva* specie

In this aspect, (Baharara, *et al*., 2014) have reported the utilization of the *Saliva officinalis* aerial parts aqueous extract as eco-friendly reducing as well as stabilizing agent for the bio-synthesis of spherical 1 to 40 nm size range silver nanoparticles with average size 16.5 ± 1.2 nm from silver nitrate at 37 C^0 for 3 hours. FTIR have reported that the plant phytochemicals exploited good interaction with the silver nanoparticles. The synthesized silver nanoparticles have dose dependent anti-angiogenic as well as cytotoxic influence through their action on the endothelial cells of blood vessels in a chick chorioalantoic membrane model at doses 50, 100, 200 μg/mL without exhibiting any morphological and embryonic alteration. The authors have emphasized that these nanoparticles exhibit their anti-angiogenic effect via prohibiting the vascular endothelial growth factor (VEGF) that blocks the cellular proliferation, migration, and capillary-like tube formation of bovine retinal endothelial cells like PEDF, hence, new blood vessels formation and probably be promising anti-angiogenic anticancer agent at high doses while, at low doses they does not destroy the vascular organization [57]. Lateron, (Verma, *et al*., 2016) have reported the utilization of the 5% concentration of aquatic fern, *Salvinia molesta* leaves aqueous concentration as reducing as well as stabilizing agent for the bio-synthesis of spherical having face centered cubic crystal lattice and 1-35 nm range size/average size of 12.46 nm silver nanoparticles from 8.0 mM silver nitrate within 35 minutes via photo-catalytic synthesis at 36 C^0. The FTIR results have revealed that the extract phytochemicals containing hydroxyl, carboxyl, and amino groups are contributing to the bio-synthesis which are mostly involved in the structures of by tannins, flavonoids, phenolic compounds and proteins. In fact, the authors have speculated that primary mechanism of bioreduction involve proton removal along with electron transfer from the tannins content in the extract, while, the secondary mechanism is based on the involvement of the sugar content in the extract as an alternative bioreductant. However, the proteins, sugar as well as phenolic content of the extract acts as nanoparticles stabilizing agents through the involvement of their OH and NH_2 functionalities. They also have demonstrated that these bio-synthesized nanoparticles exploite efficient antibacterial agents against *Staphylococcus aureus* gram positive as well as *E. coli* gram negative bacteria with MIC values of 10.50 μg/mL and 13.0 μg/mL respectively. Remarkably, they have been more effective against gram negative bacteria than the gram positive bacterial specie although it is weaker than that of the plant extract and silver nitrate, yet the silver nanoparticles are of faster onset. It is necessary to note that the smaller nanoparticles of 10 nm average size exhibit greater antibacterial activity compared to the larger one due to their electrostatic potential of interaction with the bacterial wall [58]. Interestingly, *Salvia officinalis* leaves are rich in various phenolic compounds such as flavonoids, carnosic, rosmarinic, caffeic and salvianolic acids which are mostly exist in the alcoholic extract on one hand [59]. On the other hand, the silver nanoparticles have been thoroughly reported to exhibit anti-angiogenic activity [60].

2.6. *Nymphaea* specie

The methanolic extract of *Nymphaea nouchali* dissolved in dioxin is used for the formulation of a good *in vitro* stability phytosome with particle size of 268 nm of its extract through reaction with phosphotidyl ethanolamine in tetra hydrofuran using 1:8 ratio of mixing as a promising drug delivery (89% cellular entrapment) dosage form of improved extract or levimasole diffusion rate with minimum side effect [61]. In addition, (Maji, *et al*., 2019) have reported the utilization of 15% concentration of the *Nymphaea nouchali* leaves aqueous extract as reducing and stabilizing agents in the bio-synthesis of 54.7 nm average size gold nanoparticles from $HAuCl_4.3H_2O$ when mixed in 1:2 ratio in single step. The extract phytochemicals are powerful reducing agent that is capable of reducing gold cation Au^{+3} to elemental gold besides acting as capping agents coating the gold nanoparticles hence preventing their agglomeration. In addition, the authors have reported that these nanoparticles exhibit potent concentration dependent *in vitro* antibacterial activity against *E. coli* (DH5-Alpha) at 0.12 nM MIC concentration while LD50 of 0.06 nM. The authors have emphasized that these gold nanoparticles interacts with the bacteria critical proteins leading to their denaturation as well as deactivation, hence, blocking the bacterial cell essential life processes including metabolism resulting in their death. Furthermore, the synthesized gold nanoparticles have demonstrated human serum albumin competitive interaction capacity with slight alteration in the protein secondary conformation via slight decline in the α helical along with incline of the β sheet structures while being in the HSA-AuNPs conjugate in a thermodynamically favorable state without any alteration in its chemical environment. The potential site of interaction with albumin molecule is within the Sudlow's site I (sub-domains IIA) leading to modify the albumin molecule diverse transport properties in the 438 alive cell system. Nevertheless, this interesting unexpected interaction is supposed to be beneficial for drug delivery and/or receptor as well as tissue targeting [62]. In another study, (Asadi, *et al*., 2018) have reported the utilization of white water lily, *Nymphaea alba* flower ethanolic extract for the synthesis of spherical silver nanoparticles of average size of 5-30 nm from silver nitrate as good reducing agents as compared to other plant extract at pH = 9, room temperature and mixing ratio of 1:4 after 24 hr reaction. In general, in this plant is reported to be useful for synthesis of various nanomaterials in mild condition. The FTIR results have revealed that the extract phytochemical containing OH functionalities of alcohols as well as phenols with the silver nanoparticles surface, while, the plant's proteins as well as other phytochemicals acts as encapsulating and stabilization material for these nanoparticles protecting them against agglomeration [63]. Lateron, (Mohamadi, *et al*., 2020) have utilized *Nymphaea alba* flowers extracts as reducing agents for the synthesis of semi-spherical 35 nm average size platinum nanopartilces with excellent stability via phytosynthesis. The FTIR results have demonstrated the existence of O–H, C–H, C=C, C–C, C–O functionalities stretching as well as Pt–O stretching indicating the existence of thin capping layer of the plant phytochemical including saponine, flavonoids, glycoside, alkaloid, tannin and terpenoid [64]. Furthermore; (Prasad, Savithramma, 2016) have reported the utilization of *N. tetragona* leaves extract for the rapid bio-synthesis of spherical 36 nm average/36.3-67.8 nm range sizes silver nanoparticles from 1 mM silver nitrate with good stability. The FTIR results have revealed the existence of olephenic and aromatic C=C, alkyne C≡C, aldehyde C=O, and OH functionalities related to the extract's phytochemicals take part in silver cation reduction process while, the phenolic phytochemicals OH besides, proteins amine and amide NH functionalities takes part in nanoparticles capping and stabilization processes. However, some the triangles, pentagons, hexagons and spherical shape nanoparticles with 80 nm and 88 nm size are also produced. The authors also have reported that the synthesized nanoparticles have demonstrated efficient antimicrobial activity against some human clinically pathogenic resistant bacterial species strains including four gram negative bacteria, *Bascillus subtilis, Escherichia coli*, *Klebsiella pneumonia* and *Salmonella typhimurium* with zones of inhbitions of 10 mm, 14 mm, 13 mm, and no effect respectively besides, one gram positive bacteria *Staphylococus aureus* with zone of inhibition of 11 mm. These nanoparticles have exhibited significant superiority, particularly against *E. coli* and *K. pneumonia* over the conventionally used antimicrobial drug streptomycin as well as the plant extract/silver nitrate that encourages them to suggest their utilization in the development of pharmaceutical dosage form. The potential mechanism of the nanoparticluate action involves interaction with the bacterial proteins SH groups causing their denaturation as well as DNA phosphate functionalities causing its damage leading to plasma membranes, respiratory enzymes and proton motive force disruption besides intracellular ATP depletion that bring about their bactericidal influence [65]. Moreover, (Cudalbeanu, *et al*., 2021) have reported the utilization of *Nymphaea alba* roots extract for short time synthesis of negatively charged, different shapes, mostly spherical, 321-280 nm range of size gold nanoparticles from HAuCl4 using ultrasonic activation at different salt/roots extract ratio, pHs (7, 7.8) and time of sonication (10, 40 minutes) which are significantly important for determining the particles size, charge and morphology. Nevertheless, five groups of nanopartilces are synthesized AuNPR4 < AuNPR3 ≈ AuNPR2 < AuNPR5 ≈ AuNPR1 of different shapes coexisting in spherical, quasi-spherical, trianglular and star forms, however, some of the synthesized nanoparticles have size range of 587–628 nm, besides, an elevated salt/roots extract ratio is correspondent to larger hydrodynamic size of > 20 nm gold core although similar influence is observed in case pH < 7 and short sonication time. The FTIR results have revealed the existence of OH, carboxyl group C=O, aromatic ring C=C, functionality stretching of the extract phytoconstiteunts particularly the polyphenolic compounds including hydroxyflavonoids and condensed tannins, yet they are available in the nanoparticles in low concentration particularly those of small sizes, that participate in the gold cation Au^{+3} reduction owed to their antioxidant capability, particularly at pH =6.4 although it does not allow the interaction, that interact with the gold particle through their hydroxyl groups via complexation, besides, acting as capping as well as stabilizing agent. The actual gold nanoparticles size is actually much smaller than the hydrodynamic one as they later one includes the coating thin layer of the roots extract phytochemicals which are also responsible for their colloidal property as well as morphological diversity of the synthesis nanoparticles. The authors have reported that the synthesized gold nanoparticles have exploited various physicochemical properties dependent (size and morphology) biological activities including antioxidant, antimicrobial as well as anticancer activities. Both of the antimicrobial as well as antineoplastic activity is particle size inversely dependent since as the particle size decreases the antimicrobial as well as the antineoplastic influence increases. The bio-synthesized gold nanoparticles are investigated for their antimicrobial influence against *Staphylococcus aureus* Newman and *Escherichia coli*ATCC25922. The AuNPR4 nanoparticles processing the smallest size have exhibited the greatest antimicrobial influence against the *S. aureus* at MIC = 100 μg Au/mL, while, exploiting antimicrobial influence against *E. coli* at MIC = 200 μg Au/mL. However, the AuNPR1 and AuNPR3 gold nanoparticles are also effective against the *S. aureus* and *E. coli,* yet, the AuNPR2 have exploited the lowest antimicrobial activity. In addition, AuNPR1 nanoparticles are ineffective against *E. coli*, while, the AuNPR2 and AuNPR5 are ineffective against the two bacterial strains as these nanoparticles have the biggest hydrodynamic size as they have the lowest polyphenolic and flavonoids phytochemical content attributed to low pH phytochemicals-nanoparticles interaction hindrance. All kinds of the bio-synthesized gold nanoparticles are of no antifungal activity as compared to the plant root extract that is effective against *Candida glabrata*. Furthermore, the synthesized gold nanopartilces are investigated against A2780 cisplatin-sensitive ovarian cancer cells while retaining some of their antimicrobial activity. However, besides being of nanoparticle size and incubation time dependent, they also have exploited concentration dependent antineoplastic activity with IC_{50} values of 108.7 $\pm$ 15 μg Au/mL, >>100 μg Au/mL, 51.9 $\pm$ 7.7 μg Au/mL, 33.5 $\pm$ 6.3 μg Au/mL and 136.1 $\pm$ 15 μg Au/mL for AuNPR1, AuNPR2, AuNPR3, AuNPR4 and AuNPR5, respectively. Nevertheless, AuNPR3 and AuNPR4 have processed the lowest IC_{50} values as they have the smallest hydrodynamic size that enhances their cancer cell internalization while being of the least cytotoxic influence at this concentration against the normal V79 fibroblasts. Indeed, the authors have postulated the gold nanoparticles antineoplastic activity is related to their size, morphology, charge as well as surface chemistry, but, the size of the nanoparticles are the most important one and the affect cell type is also involved. They have related the nanoparticles anticancer activity to the cancer cells capability to internalize them via transmembrane diffusion, protein channels or receptor-mediated endocytosis enormously expressed at the cancer cells membranes. However, gold nanoparticles of hydrodynamic size greater than 100 nm are exclusively uptaken via receptor mediated endocytosis. In addition, there is selective cancer cell uptake to gold nanoparticles of >50 nm size as compared to normal cells. The authors also have emphasized that the AuNPR3/4 of moderate cellular selectivity and effective anticancer mechanism agents can be used for anticancer drugs/extracts site specific delivery to the ovarian cancer cells besides being therapeutic agents themselves. In addition, with exception of AuNPR2, as they contain the lowest phytochemical content, all of the bio-synthesized nanoparticles have demonstrated greater antioxidant influence than the plant root extract [66].

2.7. ***Nasturtium* officinale**

Nasturtium officinale R. Br. Leaves aqueous extract as reducing and capping agents have been utilized for the bio-synthesis of cubic structure 10-50 nm range (36 nm average, 27 nm calculated) size silver nanoparticles of selective bactericidal influence against *S. aureus*. However, the amount of the extract used is critical for determining the size and size disparity of these nanoparticles [67]. In addition, the *N. officinale* leaves extract is been used for the eco-friendly bio-synthesis of hexagonal wurtzite, 50-60 nm size range zinc oxide nanopartilces as phyto-reducing as well as phyto-capping agents using hydrothermal diffraction condition. These nanoparticles are functionalized with the plant extract phytochemicals through C- and O-binding [68]. Furthermore, (Oraibi, 2016) have reported the utilization of *N. officinale* leaves aqueous and ethanolic extracts for the bio-synthesis of copper nanoparticles. The mixtures of *N. officinale* aqueous extract-copper nanoparticles solution (of 1.0 mg/10 ml concentration) at ratio of mixing 1:1 (v/v) and *N. officinale* aqueous extract-copper nanoparticles solution (of 0.5 mg/10 ml concentration) at ratio of mixing 1:1 (v/v) have exhibited antimicrobial activity against the gram positive bacteria *Staphylococcus aureus* and *Streptococcus pyogenes* and the gram negative bacteria *Escherichia coli* and *Pseudomonas aeruginosa*.Similarly, the mixtures *N. officinale* ethanolic extract-copper nanoparticles solution (of 1.0 mg/10 ml concentration) at ration of mixing 1:1 (v/v) and *N. officinale* ethanolic extract-copper nanoparticles solution (of 0.5 mg/10 ml concentration) at ration of mixing 1:1 (v/v) have exhibited antimicrobial activity against the gram positive bacteria *Staphylococcus aureus* and *Streptococcus pyogenes* and the gram negative bacteria *Escherichia coli* and *Pseudomonas aeruginosa*. Interestingly, all the four mixtures have no significant variation in their antimicrobial influence as well as with the positive standard antibiotic cefotaxime at concentration 250 mg/10ml, yet, the highest exerted antimicrobial activity against *Staphylococcus aureus*, intermediate effect against *E. coli,*while, the lowest activity against *Pseudomonas aeruginosa* particularly at *N. officinale* ethanolic extract-copper nanoparticles solution (of 1.0 mg/10 ml concentration) 1:1 mixture [69]. Furthermore, (Shaheen, Ahmad, 2020) have reported the utilization of *Nasturtium officinale* leaves hydroalcoholic extract for the synthesis of 40.1 nm average size mobdium oxide (MoO_3) nanopartilces from ammonium heptamolybdate tetrahydrate ($H_4Mo_7N_6O_{24}.4H_2O$) as reducing and stabilizing agnets. The FTIR results have revealed the involvement of the plant phytochemical of D-alanine, octodrine, decanoic acid, and cyclohexylethylamine as reducing agent while the aliphatic, aromatic amines, alcohol carboxylic acid, esters, and ether functionalities of phenols, flavonoids, acetic acid, D-alanine, and octodrine as capping and stabilizing agent [70]. Moreover, a nanosize fine spherical shape sorbent copper and sulfide into the tetragonal structure of SnO2-nanoparticles loaded on activated carbon of size range of 20-30 nm is bio-synthesized for the extraction, purification, and quantification of quercetin in the 80% hydromethanolic of watercress (*Nasturtium officinale*) extract with maximum sorption capacity of 39.37 mg/g with recovery values ranging from 90.3% to 97.28% [71].

Moreover, (Bayrami, 2019) have reported that watercress (*Nasturtium officinale*) leaves extract is utilized in the bio-synthesis of zinc oxide nanoparticles as reducing as well as capping agents using ultrasound-microwave joined activation reaction 1000W at pH=10.0 from $Zn(NO_3)_2{\cdot}6H_2O$. However, the ultrasound activation have lead to spindle-like zinc oxide nanoparticles which gives rise to spherical shape ones besides size shrinkage via phytochemicals capping that interacts strongly with the surface of the nanoparticles. In addition, the capping phytochemicals also involved in light mediated activation and hexagonal state reforming of the zinc oxide nanoparticles to the globular shape, hence, enahnce the morphological, optical, as well as surface properties. Zinc oxide nanoparticles and extract/zinc oxide nanoparticles combination have exerted a considerable antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli* at concentration $\geq$ 0.2 mg/ml although both are very effective at concentration of $\geq$ 0.4 mg/ml, however, the plant extract significantly potentiate the nanoparticles antimicrobial influence even at 0.1 mg/ml, as there is some degree of resistance against the zinc oxide nanoparticles alone. Besides, the MIC of zinc oxide and zinc oxide/extract combination against *S. aureus* at 0.4 mg/ml. The authers have attributed the synergestic potentiating influence of the *Nasturtium officinale* extract to its phytochemicals such as phenolic compounds and glucosinolates (the precursor of 2-phenylethyl isothiocyanate) which are potent antimicrobial agents. Furthermore, the authors have reported that the bio-synthesized zinc oxide have exerted hypoglycemic as well as antihyperlipidemic influences in alloxan- induced type II diabetes mellitus Wistar rats model as they declines the fasting blood glucose, and lipid profile including total triglyceride, total cholesterol, and high-density lipoprotein cholesterol particularly the Ext/zinc oxide as the extracts phytochemicals improve these nanoparticles. They also have showed that spindle shape zinc oxide and spherical shape zinc oxide/extract are those which have antidiabetic influence with glucose lower effect much potent than insulin especially in case of zinc oxide/extract as it gives rise to insulin level close to control however, the plant extract phytochemical have insulinotrpic influence. In addition, these two agents zinc oxide nanoparticles as well as zinc oxide/extract nanoparticles cause significant reduction in the blood lipids such as triglycerides that is close to control while, the blood HDL is doubled, however, the zinc oxide/extract nanoparticles are of the most pronounced antihyperlipidemic influence explained by the phytochemicals synergestic action. Thus, the leaves extract of the plant are much effective than the zinc oxide nanoparticles and zinc oxide/extract nanoparticles [72].

Furthermore, (Pourhassan-Moghaddam, *et al*., 2014) have reported the utilization of watercress (*Nasturtium officinale*) total extract as reducing, stabilizing as well as capping agents for the eco-friendly bio-synthsis of chargeless, phytochemicals capped and spherical gold nanoparticles of 16 ± 4 nm avarge via a hydrothermal reaction within 9 minutes at 91 C^0 at 1:6 ratio of mixing which is pH dependent as large aggregate occurs at pH =3 as compared to pH =12. The reaction can happens at 37 C^0 however, with a much slower rate while the reaction proceeds at faster rate at acidic pH =4.75, however, a 1:4 ratio of mixing leads to 17 ± 5 nm average size spherical gold nanoparticles. In fact the hydrodynamic size of the bio-synthesized nanoparticles is within 50 and 250 nm size ranges for the 1:4 ratio of mixing and 150–350 nm for 1:6 ratio of mixing. The potent plant extract phytochemical antioxidants that reduce the gold cation into elemental gold as demonstrated by the FTIR results. The main phytochemicals involved in reduction as well as capping of the gold nanoparticles are mostly phenolic as well as flavonoids including quercetin 3'-methyl ether (isorhamnetin), hydroxycinamic acid, flavones apigenin, luteolin, flavonols kaempferol, lutein and rutin (quercetin-3-o-rutinoside), and chicoric acid besides, carotenoids such as beta-carotene which takes part of the nanoparticle structure. Interstingly, the principle reducing agent within the plant extract are chicoric acid, quercetin-3-O-rutinoside, isorhamnetin and glucosnastrutiin which mediate the reduction reaction even faster than citrate, however their hydroxyl functionalities are involved in the reduction of the gold cation Au^{+3} while the rest of their molecules are involved in the gold nanoparticles capping. In addition, the author have reported that other biomolecules are involved in the capping of the synthesized nanoparticles including alkanes, proteins, nucleic acids and iodinated compounds as illustrated in figure 1 quoted from (Pourhassan-Moghaddam, *et al*., 2014) report [73]. The authors have also reported the safety/biocompatibility of the synthesized nanoparticles as they do not exhibit an antigrowth influence against normal cells, thus, they can be used for drug delivery, diagnosis (as contrast media for imaging tools) as well as treatment of various pathological conditions due to their capability to incorporated various hydrophilic/hydrophobic molecules such as drugs, peptides, nucleic acids, proteins, dyes and phytochmeicals via the interaction with their capping phytochemicals functionalities. The authors also speculate the potentiality of their use for cancer photothermal therapy as well as subcellular immune staining particularly those of large size [73].

Interestingly, (Dadashpour, et. al, 2018) have reported the synthesis of watercress (*Nasturtium officinale*) extract loaded electro spun nanofibrous mats of potent antioxidant potential, cytoprotection, adhesion properties and stemness proliferation enhancing/preservation of adipose derived stem cells [74]. In addition, (Adlravan, *et al*., 2021) have reported the formulation of 110-140 nm size range nanoencapsules of *Nasturtium* officinale extract-loaded poly (ethylene glycol)-b-poly (d,l-lactide-co-glycolide) (PEG-PLGA) nanoparticles with concentration- and time-depedent cytotoxic influence against human lung carcinoma A549 cells with IC_{50} values of 80, 70, and 40 µg/mL for 24, 48, and 72 h, respectively. Besides, the nanocapsules have exerted an apoptotic influence of 63.3% and 72.3% at the concentrations of 40 and 60 µg/mL, respectively via promoting p53, Bax, and Caspase 3 expression while reducing the expression of bcl-2 and CyclinD1 [75].

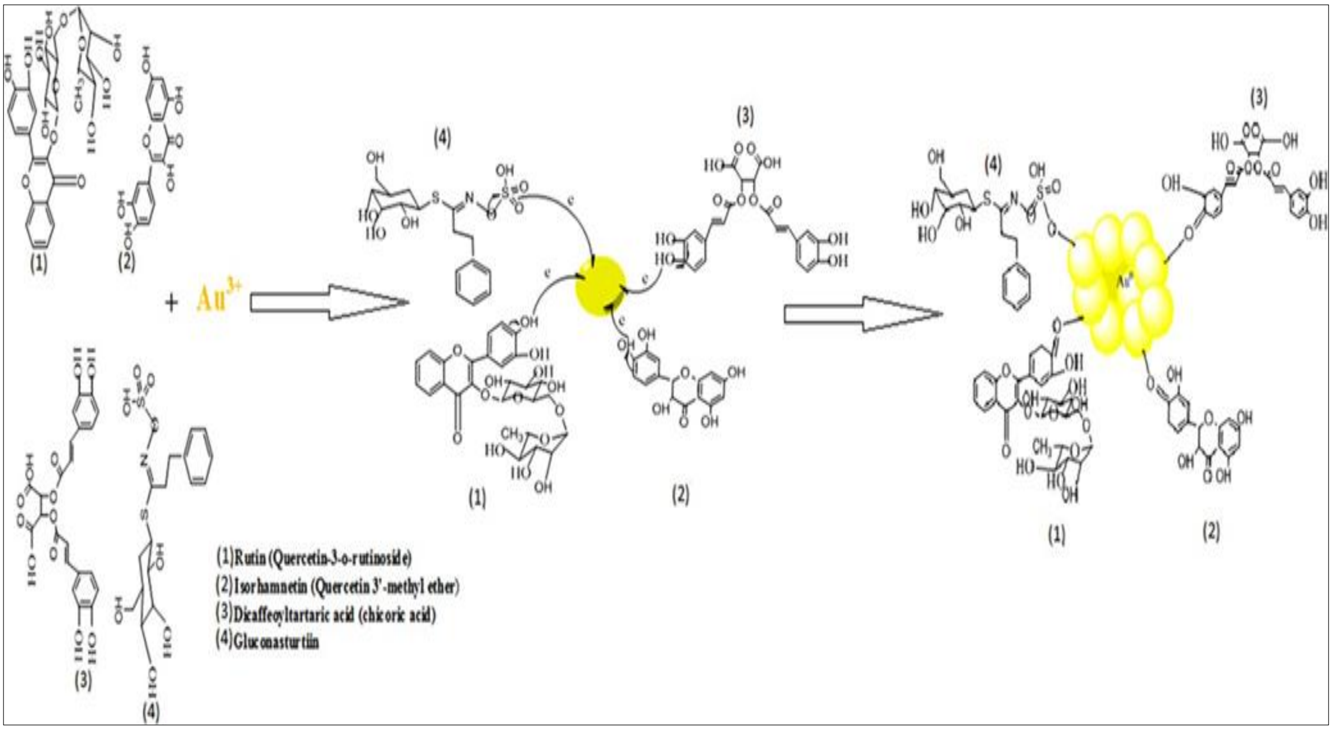

Figure 1 Mechanism of gold nanoparticles biosynthesis using watercress (*Nasturtium* officinale) total extract [73]

3. Bacopa monnieri

In this context, (Badrelden, *et al*., 2018) have reported the utilization of *Bacopa monnieri*, extract for the eco-friendly bio-synthesis of isotropic spherical uniform 40.3 nm average size silver nanoparticles from as a reducing and stabilizing agent. The FTIR results have indicated the existence of hydroxyl and amine functionalities stretching of the extract bioactive phytochemicals of alcohols, ketones, aldehydes and carboxylic acids within the structure of the silver nanoparticles bind through their carbonyl and amine functionalities, besides, being capped and stabilized with other phytochemicals such as terpenoids as well as proteins preventing their agglomeration [76]. In another study, (Mahitha, *et al*., 2011) have reported the utilization of *Bacopa monniera* ethanolic extract as reducing and capping agents for the synthesis of isotropic mostly spherical shape 10-30 nm range/22 nm average size silver nanopartilces from 0.025 M silver nitrate at room temperature within 1 hour. However, silver nanoparticles of average size around 10 nm are obtained using whole plant extract. The FTIR results have revealed the existence of alcoholic hydroxyl, carboxyl, amine, ester and ether functionalities stretching corresponding to proteins and plant extract phytochemicals such as terpenoids included in the bio-synthesis process. The synthesized nanoparticles have exhibited effective antimicrobial influence against *staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumonia* and *Bacillus subtilis* at 10 µl Ag nanoparticles in a manner comparable to the positive standard gentamycin. Nevertheless, their most potent bactericidal influence is exploited against *Bacillus subtilis* thus the authors speculated their potentiality of their use in both food and pharmaceuticals industries [77]. Lateron, (Jawarkar, *et al*., 2019) have reported the utilization of aqueous *Bacopa monnieri* leaves extract for the bio-synthesis of 73.5 nm average size silver nanoparticles from silver nitrate 15 minutes at room temperate. However, the synthesized silver nanoparticles have exploited a considerably promising doe-dependent antioxidant influence at 10 µg/ml and 20 µg/ml [78]. In addition, (Khdary, *et al*), have reported the utilization of three solvent aqueous, ethanol, and dichloromethane extracts for the synthesis of three spherical less than 100 nm different sizes 85±12 nm, 70±16 nm, 50±7 nm silver nanoparticles respectively from silver nitrate at different pH values. The plant extract potent antioxidant phytochemicals such as bacopaside and bacosterol contribute for reduction, capping as well as maintaining uniform particle size indicated by the FTIR results of olephenic C=C as well as phenolic OH functionalities stretching. These silver bio-synthesized have exploited nanoparticle- size as well as concentration-size antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli.* The smallest size 50 nm groups of nanoparticles have the most potent antibacterial activity at 15 µg /mL followed by that of of sizes around 70 nm at the same concentration [79].

Moreover, (Suganya, *et al*., 2018) have reported the utilization of methanolic *Bacopa monneri* leaves extract for the photosynthesis of isotopic spherical and polygonal shape uniform >35 nm (35-45) size silver nanoparticles from silver nitrate under sunlight within 30 minutes. The FTIR have indicated the involvement of flavonoids, terpenoids and aliphatic amine phytochemical as reducing as well as capping/stabilizing agents along with proteins/enzymes occur as a thin organic layer coat surrounding the silver nanoparticles as part of their building via interaction through their oxygen and nitrogen functionalities. They also have reported that these bio-synthesized nanoparticles have exhibited antibacterial activity against *Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae, Salmonella typhi* and *Proteus vulgaris*, however, their antimicrobial influence is greatest against *E. coli* and *P. vulgaris* occur at MIC of (26 ± 1.5 mm) and (18 ± 1.6 mm) while exhibiting similar antimicrobial influence at MIC of (15 ± 0.8 mm). They have emphasize that their antimicrobial influence is due to the electrostatic interaction between the positively charged silver nanoparticles and the negatively charged membrane of the bacteria along with phytochemical triggered oxidative stress causing cell membrane damage due to the cell membrane macromolecules proteins as well as lipopolysaccharides denaturation particularly in gram negative bacteria *E. coli* resulting in cell death, thus, can be used for counteracting pathogenic bacteria on one hand. On the other hand, the authors also have reported that these nanoparticles have also exhibited antineoplastic influence against human lung adenocarcinoma cell line (A549) with GI_{50} of 20 µg/ml within 24 hours through their apoptotic effect and DNA damage/fragmentation which is more enhanced than the anticancer drug etoposide although at 40 µg/ml concentration of the synthesized nanoparticles causes 100% cell death. The authors have emphasized that the coating phytomolecules have implication in their antiproliferative action. In addition, the accumulation of the silver cation in the cancer cell nucleus signals to the DNA oxidative damage, hence, affecting the cell division. Besides, silver nanoparticles decline the intracellular glutathione level, hence, inducing oxidative stress of the cellular respiration to bringabout cell damage as well as inclining the number of apoptotic/necrotized cells. However, they have postulated that their cytotoxic effects are in part related to silver cation release. Thus, they have concluded that these bio-synthesized nanoparticles mat have implications in cancer therapy as well as drug delivery [80]. In another study, (Mahitha, *et al*., 2015) have reported the utilization of aqueous *Bacopa monniera* extract as reducing, stabilizing and capping agents that stabilized an eco-friendly bio-synthesized 5-30 nm size range silver nanoparticles from silver nitrate within 2 hours, most of them smaller than 10 nm. The FTIR spectra results have indicated the existence of alcohols, phenols, primary aromatic amines, carboxylic acids, ethers and esters of the extract alkaloids, saponins and sterols, terpenoids and other phytochemicals besides proteins within the structure of the synthesized nanoparticles structures. The authors have reported that the co-administration of the synthesized silver nanoparticles have exerted antioxidant as well as aluminum induced CNS, liver and kidney toxicities that at a dose of (5 mg/kg) in albino male mice model, however, administration of these nanoparticles after triggering aluminum toxicity related oxidative stress no significant changed have been observed. Co-administration of these nanoparticles significantly decline lipid peroxidation involving incline in the superoxide dismutase, catalase and glutathione peroxidase activities in the brain, liver and kidney, thus, preventing tissue damage. The authors have emphasized that the nanoparticles antioxidant influence is related to the phenolic, triterpenoid, and saponoins antioxidant nanoparticles coating plant extract phytochemicals that counteract the reactive oxidation species, besides, concluded that these nanoparticles are effective management to the aluminum induced toxic side effects [81].

Moreover, (Nellore, *et al*., 2013) have reported the utilization of aqueous *Bacopa monnieri* leaves extract of mostly spherical 5-20 nm size range platinum nanoparticles from Chloroplatinic acid in aqueous media as reducing, stabilizing and capping agents via the extract's phytochemicals. The FTIR results have revealed the existence of amines, alcohols, ketones, aldehydes, and carboxylic acid functionalities that are corresponding to phytochemical such as flavonoids, as well as plant extract proteins coat the platinum core of the nanoparticles stabilizing them as well as preventing their agglomeration. The authors have demonstrated that these nanoparticles are suitable for management of oxidative stress induced disease such as Parkinson's disease in zebra fish model due to the antioxidant as well as neuroprotective potential of the nanoparticles coating phytochemical that increase the central dopamine/its metabolites and GSH levels while, enhancing the activity of superoxide dismutase, glutathione peroxidase and mitochondrial complex I besides, increasing the locomotors activity. However, the combination of plant extract- platinum nanoparticle have a synergistically improved neuro-protective influence at concentration of 0.4 μmol of BmE-PtNPs combination since it significantly increases the antioxidant enzymes activity as well as biomoleucles levels such as GSH, SOD, catalase, complex I and glutathione peroxidase besides scavenging free radicals such superoxide anion radicals, and hydrogen peroxide [82].

Furthermore, (Babu, *et al*., 2013) have reported the utilization of 4% ethanolic *Bacopa monnieri* leaves extract as reducing, stabilizing and capping agent for the bio-synthesis of mostly spherical 3-45 nm range/ 11 nm average size gold nanoparticles from $HAuCl_4$ within short time (15 minutes) under UV radiation while mostly spherical/some hexagonal 5-100 nm range/21 nm average size gold nanoparticle under hydrothermal synthesis condition. The relative safety/biocompatibility of the synthesized gold nanoparticles when applied to the human cancer cell lines (HeLa, MCF-7) is related to the extract phytochemical coating layer. The bioactive coating phytomolecules including first, brahmine, nicotine and herpestine; alkaloides, second, D-mannitol and hersaponin, acid A, and monnierin; saponines, third, bacopasaponins (bacosidesA1, A2, A3, A4, N1, N2), fourth, luteolin and apigenin, flavonoids, fifth, betulic acid, stigmasterol and beta-sitosterol; steroids which all acts as bio-reduction agent for the nanoparticles synthesis via electrons donation. The authors have speculated that these nanoparticles are suitable for imaging as well as drug delivery [83].

In addition, (Faisal, *et al*., 2022) have reported the utilization of *Bacopa monnieri* leaves extract as reducing, capping as well as stabilizing agents for the synthesis of monoclinic-shaped 34.4 average size copper oxide nanoparticles while some other pristine 22 nm average size copper oxide nanoparticles are crystraline in nature. Nevertheless, the salt content, pH, and rate of reaction since the high pH and fast reaction rate lead to large size particles as well as aggregation. The FTIR results have revealed the existence of C=C of alkenes, N-O nitro, OH carboxylic acid stretching vibration corresponding to the extract phytochemicals such as flavonoids and phenols within the structure of bio-synthesized copper oxide nanoparticles. The safety/biocompatibility of the bio-synthesized is investigated against the human blood cells/hemolysis exhibiting considerable safety $\leq$ 12.5 µg/mL while at concentration of 400 µg/mL exhibited considerable cytotoxicity around 5%, yet, these nanoparticles hemolysis potential is size dependent. The authors have reported that these nanoparticles have exhibited considerable antibacterial, anti-diabetic, analgesic and anti-inflammatory influences, nevertheless, their anti-inflammatory activity at dose of 400 mg/ml is superior to diclofenac at 100 mg/ml dose in carrageenan 1% -induced rat hinds paw edema. While, they have comparable but slightly weaker hypoglycemic influence at a dose of 14 mg/kg bw orally individually as well as at a dose of 7 mg/kg orally in combination with insulin, to subcutaneously administered insulin at a dose of 0.4/ 50 g in streptozocin-induced diabetes in mice model on one hand. On the other hand, the antimicrobial influence of the biosynthesized copper oxide nanoparticles have been investigated against *Helicobacter felis*, *Helicobacter suis*, *Helicobacter salomonis* and *Helicobacter bizzozeronii*, at concentration of 5 mg/ml however, the most liable bacterial specie are *H. suis* and *H. felis* while the least susceptible specie is *H. bizzozeronii* but still less effective than the positive control ampicillin. Remarkably, these nanoparticles are bactericidal at higher concentration while, bacteriostatic at lower concentration (< 5 mg/ml). In addition, at dose of 400 mg/kg maximum latency time of 7.14 ± 0.12 second was after 90 min revealing 60-65% analgesic activity, whereas, they inhibit edema by 74% after 48 hrs while 82% after 21 days which greater than the positive standard diaclofenc at a dose of 100 mg/kg that exhibit 24% edema inhibition while 73% after 21 days. The authors have proposed that the mechanism of the synthesized copper oxide nanoparticles, is through inhibiting altering the migration of leukocytes, hence, prohibiting the inflammation and arthritic processes. In addition, the authors also have speculated that the copper oxide nanoparticles capping extract phytochemicals have contributed to their multiple biological activities [84].

Recently, (Lala, 2020) have reported that starch capped and stabilized < 20 nm copper nanoparticles enhances the production of *Bacopa monnieri* (L.) phytochemicals such as saponins, alkaloids, phenolics, flavonoidsat sub-toxic concentrations of 5 mg/L [85]. However, bacobasaponine have been reported to exhibit effective antilieishmanial influence along with minimum nephrotoxic side effects when delivered as nanoparticles, microspheres as well as niosomes [86]. Furthermore, (Mathur, *et al*., 2016) have proposed the utilization of nanoparticles size/base liposomes, polymeric micelles and polymersomes for site specific delivery of *Bacopa monnieri* pharmacologically active bacosides [87]. In addition, (Habbu, *et al*., 2013) have reported the phytoformulation nanoparticle size *Bacopa monnieri* extract-phospholipid (phoaphatidylcholine) complex to be administered as antiaging (antiamnesic) agent in the amnesic mice model which have demonstrated better activity the the neet extract as the extract-phospholipid complex has provided higher bacopaside-I and bacopaside-II [88]. Recently, (Kumar, and Garg) have reported the formulation of Bacoside rich *Bacopa monnieri* extract loaded solid lipid nanoparticles of good blood brain barrier penetration/controlable drug release using glyceryl monostearate using hot homogenization followed by sonication method for treatment of Alzehimer's disease. the synthesized solid-liquid nanoparticles is almost spherical shape but, with irregular surfaces, their average size is < 200 nm, able to prolong the drug release upto 24 hours, stable over refrigeration temperature for 3 monthes, besides, the drug entrapment in these nanoparticles is around 82% [89]. Lateron, (Deshpande, *et al*., 2021) have reported the formulation of novel 10-1000 nm size range physiologically well-tolerated *Bacopa monnieri* ethanolic extract loaded solid-lipid nanoparticles as a biodegradable phospholipid nano-carrier of therapeutic phytochemicals as neuro-protective agents. The process was size, surface functionalities, drug loading, drug release profile and serum stability good controllable one [90-91].

4. Conclusion

Like other plant extracts as well as naturally occurring biomaterials, aquatic plants extracts particularly those reported to be habituated in the Iraqi southern marshlands have been extensively reported to be eco-friendly, efficient and economic tool for the synthesis of nanoparticles of various shape and size exhibiting different biological activities particularly antibacterial as well as anticancer activities. Besides, being potentially useful drug nano-carrier including bacosides of *Bacopa monnieri*. The utilized aqueous and other extracts of aquatic plants including *Typha, Ranunculus, Potamogeton, Saliva, Nymphaea,* and *Nasturtium,* specie, as well as *Ceratophyllum demersum, Mentha aquatic,* *Nasturtium officinale, Ranunculus laetus* and *Bacopa monnieri* are involved for the bio-synthesis of nanoparticles that exhibited various biological activities including antibacterial, anticancer, antidiabetic as well as other activities.

Compliance with ethical standards

Acknowledgments

We would like to thank the College of Medicine, and Marshes Center - University of Thi Qar for support.

Disclosure of conflict of interest

The authors confirm that there is no conflict of interests.

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