International Journal of Zoology and Applied Biosciences ISSN: 2455-9571
Volume 10, Issue 5, pp: 49-57, 2025
https://doi.org/10.55126/ijzab.2025.v10.i05.007 http://www.ijzab.com

Research Article

SELENIUM NANOPARTICLES SYNTHESIZED THROUGH *PONTEDERIA CRASSIPES* EXTRACT: A COMPREHENSIVE STUDY ON CHARACTERIZATION AND FUTURE APPLICATIONS

*R. Bannari and Litty Koria

PG & Research Department of Zoology, L.R.G. Govt Arts College for Women, Tiruppur, Tamil Nadu. India

Article History: Received 26th July 2025; Accepted 29th August 2025; Published 30th September 2025

ABSTRACT

This study aims to explore innovative approaches for vector control, specifically targeting the *Aedes aegypti* mosquito. A progressive methodology utilizing green synthesized selenium nanoparticles (Se-NPs) derived from *Pontederia crassipes* as a novel biocontrol strategy is proposed in this study. The preparation of plant extract was meticulously conducted to ensure optimal phytochemical yield, followed by the synthesis of Se-NPs through environmentally friendly methods. Characterization of the synthesized nanoparticles was performed using various techniques, including UV-Vi's spectroscopy, X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and transmission electron microscopy (TEM). The findings indicate that the green synthesized Se-NPs can exhibit promising biocidal properties against *Aedes aegypti*, suggesting their potential as a sustainable alternative in dengue vector control strategies. This study highlights innovative vector management using green synthesized nano particles.

Keywords: Selenium nanoparticles (Se-NPs), Green synthesis, *Pontederia crassipes*, Biocontrol.

INTRODUCTION

Over the past 20 years, dengue fever has become much more common worldwide, which presents a serious public health risk. The World Health Organization (WHO) projected a ten-fold increase in reported cases globally between 2000 and 2019, going from 500,000 to 5.2 million. A record high was reached in 2019, with cases recorded in 129 different nations. Due to the COVID-19 pandemic and a lower reporting rate, there was a slight decline in dengue cases between 2020 and 2022. However, in 2023, there was a global upsurge in dengue cases, which was characterized by a significant increase in the number, scale, and simultaneous occurrence of multiple outbreaks that spread into previously unaffected regions. A number of novel methods are used for the control of Dengue fever. One such method for effective control is the use of Nano particles. A variety of chemical and physical techniques have been employed in the production of NPs. The chemical and physical approaches are expensive and hence biosynthesis of NPs is required. The manufacturing of NP via the green-synthesis process has shown to be economical, environmentally safe and has increasing uses across a range of industries. This environmentally friendly technique can regulate the emission of hazardous compounds. (Mikhailova, E.O. 2023)

Recently, there has been interest in the production of nanoparticles. With broad applications in domains like medicine, chemistry, biology, electronics and energy, which fills the gap between bulk material and atomic or molecular structure (Mushtaq *et al*., 2021; Alavi *et al*., 2022). According to Zhang *et al*. (2011) and Fernández *et al*. (2017), selenium is a trace element that may occasionally be classified as a metalloid. It has a wide range of characteristics and uses, such as semiconductor, thermoelectric, and catalytic activity, as well as hydration and oxidation processes. It functions as an antioxidant and guards against oxidative processes that could harm bodily tissues. Selenium has an inhibitory impact on some germs and lowers the incidence of certain malignancies, including those of the lungs, pancreas, stomach, and intestines.

*Corresponding Author: R. Bannari, Ph.D. Research Scholar, PG & Research Department of Zoology, L.R.G. Govt Arts College for Women, Tiruppur, Tamil Nadu. India, Email: bannari.mjcas-fac@mjc.ac.in.

Despite the numerous benefits that have been shown, selenium is poisonous, and excessive concentrations can have negative effects. Through the production of selenium nanoparticles (SeNPs), researchers in nanotechnology may be able to lower the element's potential and verify for toxicity. Size has a major impact on SeNPs' biological activity. These particles have more biological activity than typical selenium compounds, to the extent that 5-200 nm of selenium may effectively remove free radicals in a laboratory setting (Winkel *et al*., 2012; Sharma *et al*., 2014).

In all aquatic environments, particularly in still water environments like lakes, *Pontederia crassipes* is an invasive plant. Bioactive substances with favorable antifungal effects on the environment are present in this plant. Water hyacinth's potential as a strong and long-lasting antifungal has been demonstrated by research (Semu J Williams b.*et al.,* 2024) It is anticipated that the water hyacinth's antifungal composition would raise agricultural demands. A native plant species of the Amazon basin, *Pontederia Crassipes* has spread throughout tropical and subtropical areas, causing disastrous effects on water bodies and water systems in over 80 nations, including all of Southern Africa (Harun *et al*., 2021). Significant losses to tropical water systems and ecosystems, both economically and ecologically, have been attributed mostly due to the water hyacinth. The infamously invasive monocotyledonous free-floating water plant is ranked by the International Union for Conservation of Nature (IUCN) as one of the world's ten worst weed plants.

Numerous plants possessing bioactive qualities have been identified as crucial elements in conventional medicine and human nourishment. These naturally occurring medicinal plants include a variety of active components (extracts, oils, and phytochemicals) that may interfere with the life stages of mosquitoes, including the egg, larva, pupa, and adult. Furthermore, scientists choose plant-based treatments over toxic chemical pesticides when combating vector mosquitoes. The insecticidal properties of botanicals against vector mosquitoes have been the subject of several published articles (Pålsson & Jaenson, 1999; Ghosh *et al*., 2012; Kalita *et al*., 2013; Lupi *et al*., 2013; Rehman *et al*., 2014; Shaalan & Canyon, 2015; Tehri & Singh, 2015; Naseem *et al*., 2016; Remia *et al*., 2017; Hikal *et al*., 2017; Bekele, 2018; Ganesan *et al*., 2023). A list and discussion of 344 botanical compounds with possible mosquitocidal properties was provided by Sukumar *et al*. (1991). Senthil-Nathan *et al*. (2020) have reviewed a recent study that goes into depth into the botanicals utilized for larvicidal activity. Similarly, the plant Pontendria Crassipes is used in the present study as biocontrol agent with SeNP. Selenium nanoparticles (SeNPs) are extremely popular objects in nanotechnology. "Green" synthesis has special advantages due to the growing necessity for environmentally friendly, non-toxic, and low-cost methods.

MATERIALS AND METHODS

Materials and reagents: Selenous acid (H2SeO3), MTT 3-(4,5-dimethythiazol-2-yl)-2,5-diphenyltetrazolium bromide, DAPI 40-6-diamidino-2-phenylindole, acridine orange/ethidium bromide (Ao/EtBr), Sodium dodecyl sulfate (SDS) Were purchased from Sigma Aldrich, India. All additional analytical grade chemicals were obtained from commercial suppliers.

Collection of plant and obtaining the extract

Collection and identification of the plant species were done by standard practice and inferring them with the herbarium at Botanical Survey of India, Coimbatore, Tamil Nadu, India. Aqueous extraction from the plants were carried out as per previous report (Vetrivel, *et al*. 2019).

Preparation of plant extract

Freshly collected plant material was washed thoroughly with distilled water to remove any impurities. The plant was then air-dried at room temperature and ground into a fine powder. The powdered plant material was subjected to extraction using methanol through Aqueous extraction. The extract was filtered through Whatman No. 1 filter paper to remove particulate matter. The filtrate was then concentrated using a rotary evaporator at reduced pressure to obtain a viscous extract.

Synthesis of Se-NPs from plant extract

5 mL of C. bulbosa tuber extract was diluted with 45 mL of double distilled water (DDW), followed with the addition of 20 mL of 40 mM Selenous acid solution. The mixture solution was stirred for 24 h at 37 °C (room temperature) until the color changes from yellow to ruby red. In the end the resultant product was washed with DDW followed by centrifugation at 10,000 rpm for 10 min. The washing step was repeated several times until the impurities was removed. Finally, the red pellet was dried in freeze drier for two days and used for further study.

Characterization of Se-NPs

The rapidly synthesized Se-NPs was characterized by UV–Visible spectroscopy (SHIMADZU-1800, India). The phase formation and crystalline nature of the SeNPs was examined by Rigaku XRD at a voltage of 45 kV with Cu-Kα radiation (K=1.5406 Å). Functional groups were analyzed by FT-IR (PERKIN ELMER SPECTRUM 100 FT-IR Spectrometer). The IR (Infra-Red) spectrum can be recorded in middle region wavelength of 4000–400 cm−1 at a resolution of 4.0 -*cm−1. A suspension on a Zeta sizer Nano ZS particle analyzer (MALVERN) was used to measure the surface charge of the SeNPs. The surface shape and particles elemental analysis was carried out using FE-SEM with EDS mapping analysis (JEOL 7401 F) and HR-TEM (TECNAI G2 F30) analysis. The DLS and ZP analyzer (MALVERN ZETA sizer nano-ZS90, UK) was utilized to measure the size dimension and surface charge of synthesized SeNPs.

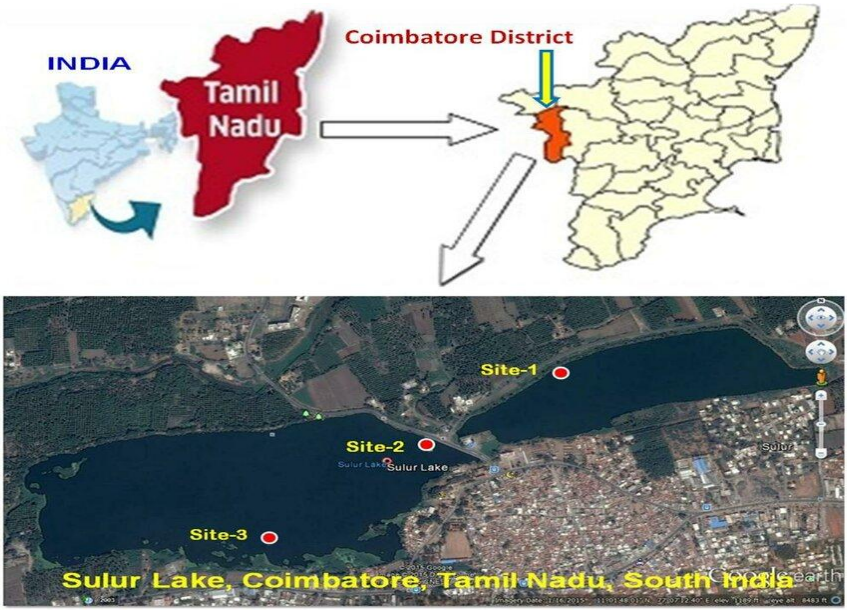


Figure 1. *Pontederia crassipes* plant was collected from Sulur lake Coimbatore, Tamil Nadu. India. Sulur is located at 11.0295°N, 77.1190°E. It has an average elevation of 340 metres (1115 feet).

Figure 2. Graphical presentation ofgreen synthesized selenium nanoparticles using *Pontederia crassipes* extract.

RESULTS AND DISCUSSION

Collecting and identifying the plant species by standard practice and preserving them in the herbarium at Botanical Survey of India, Coimbatore. Tamil Nadu. India. (Voucher No: BSI/SRC/5/23/2024-25/Tech/436). The synthesis of selenium nanoparticles (SeNPs) using *Pontederia crassipes* extract was confirmed by a color change from pale yellow to reddish-brown, indicating the formation of SeNPs.

Table 1. Shows that phytochemical screening of the *Pontederia crassipes* extract revealed the presence of various bioactive compounds including flavonoids, tannins, alkaloids, saponins, and phenols. Saponins and Terpenoids were present in higher concentrations, followed by Alkalloids, phenols and Glycosides which were present in moderately high concentrations. Flavonoids, Steroids and amino acids were present in low concentrations.

Phytochemicals	Methanol
Alkaloids	++
Phenols	++
Flavonoids	+
Tannins	-
Saponins	+++
Terpenoids	+++
Steroids	+
Carbohydrates	+
Glycosides	++
Amino acids	+
Proteins	+

+ → present in small concentration; ++ → present in moderately high concentration;

Atomic absorption spectroscopy was also used to study the concentration of selenium ions at various time trials to determining its remaining one in the supernatant.

+++ → present in very high concentration; -- → absent.

The SeNPs from the extracts of Pontendria Crassipes were characterized by Methods such as In present study SeNPs was synthesized by the *Pontederia crassipes* extract. The formation of SeNPs was confirmed by UV–vis spectral analysis. Results showed that the reduction of selenium ions and the generation of SeNPs were completed within 24 h of incubation at room temperature. The formation of ruby red colour indicated the reduction of selenium ions. The absorption spectra of the SeNPs were observed at 259 nm and the formation of such peak occurs due to the Surface Plasmon Resonance (SPR) of SeNPs. This confirms the intensity of the colour was directly proportionate to the incubation period and it was occurred due to the excitation of surface plasma resonance (SPR) as well as the polydispersity of the SeNPs (Figure 3). Table 1. Shows that phytochemical screening of the *Pontederia crassipes* extract revealed the presence of various bioactive compounds including flavonoids, tannins, alkaloids, saponins, and phenols

+ → present in small concentration; ++ → present in moderately high concentration;

Atomic absorption spectroscopy was also used to study the concentration of selenium ions at various time trials to determining its remaining one in the supernatant.

+++ → present in very high concentration; -- → absent.

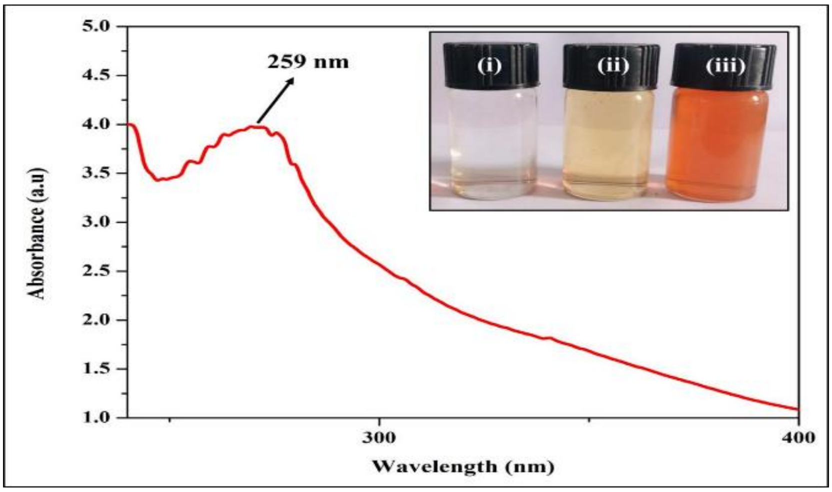


Figure: 3. UV- Visible spectrum and Chromatic variation of SeNPs after adding *extract* with 40 mM of sodium selenite solution (i)Sodium selenite, (ii) Extract, and (iii) SeNPs.

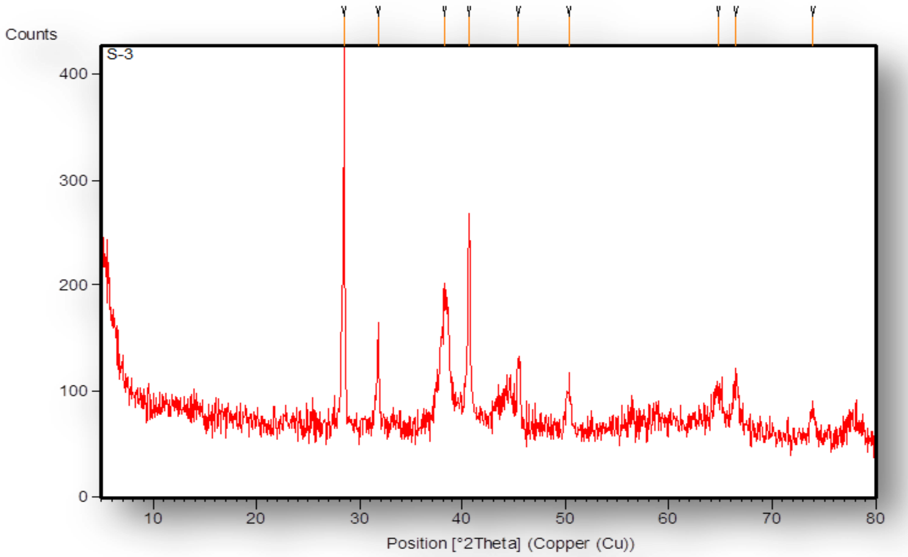


Figure 3. XRD of synthesized Se-NPs.

Figure 3 shows the XRD pattern of Se-NPs, which showed the hexagonal structure of the produced Se-NPs. The planes of the Se crystalline form (210), (202), (112), (102), (110), (101), and (100) were assigned to the usual diffraction peaks located at 2theta = 65.90, 41.83, 31.92, 43.35, 48.24, 29.61, and 23.98, respectively (JCPDS No. 06-0362). The predominant orientation occurred to plane (101), as seen by the stronger and higher peak at 2theta = 23.98 pointing to the plane (101). Figure:4 Shown in determine the potential biomolecules in charge of stabilizing and capping the selenium nanoparticles, FT-IR analysis was carried out in the current investigation. The thermocyclic amine, >N-H stretch, 2025 (N=C=S stretching isothiocyanate), 1384 (gem-Dimethyl or "iso" (doublet), 1314 (primary or secondary, OH in plane blend), 1101 (C-N symmetrical vibration of carboxylate ions), and 657 (Thioether, CH3-S-(C-S Stretch)) were the absorption bands that the aqueous extract displayed. Nearly identical peaks are produced in the green generated selenium nanoparticles. When comparing the two results, the band shift in the FTIR spectra of 3434 (heterocyclic amine, >N-H stretch), 2025 (iosthiocyanatein (-NCS), 1633 (organic nitrates), 1384 (gem-Dimethyl or "iso" (doublet), 1314 (primary or secondary, OH in plane blend), 1270 (Vinylidence C-H in-plane blent), 1101 (C-N symmetrical vibration of carboxylate ions), and 488 (polysulfides (S-S stretch) FTIR spectrum, which validates the decrease procedure. The production of SeNPs effectively relies on these functional groups.

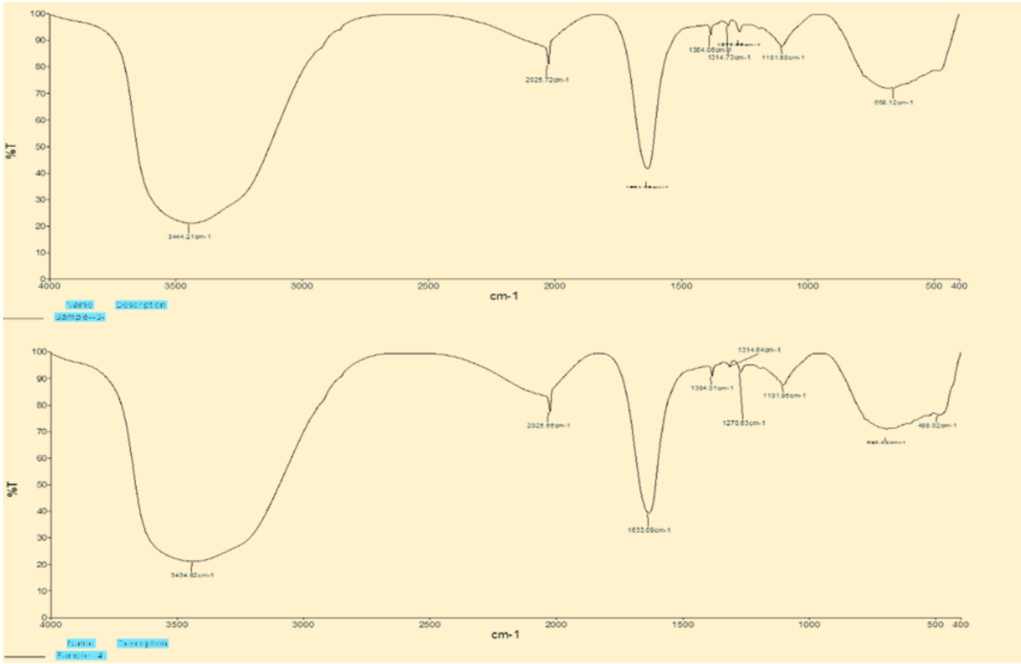


Figure 4. FT-IR spectrum of SeNPs synthesized.

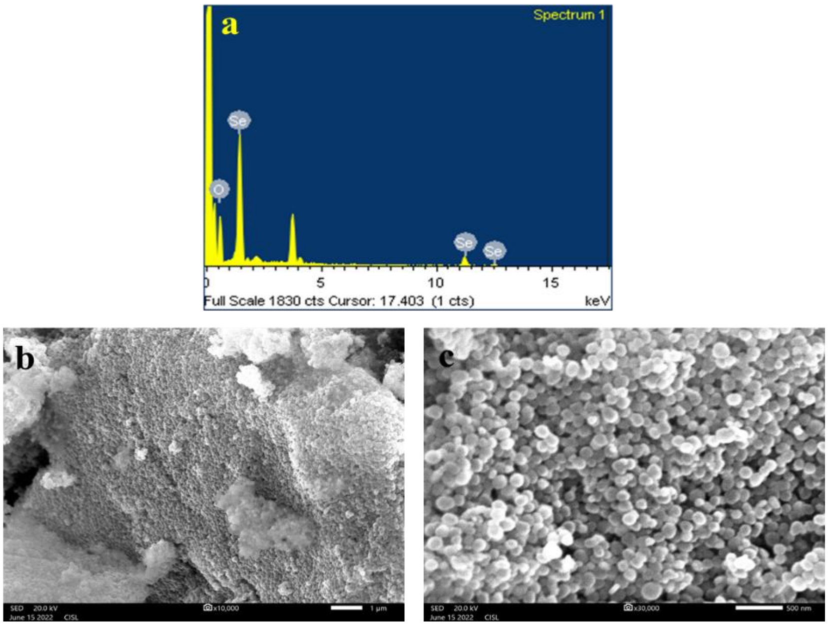
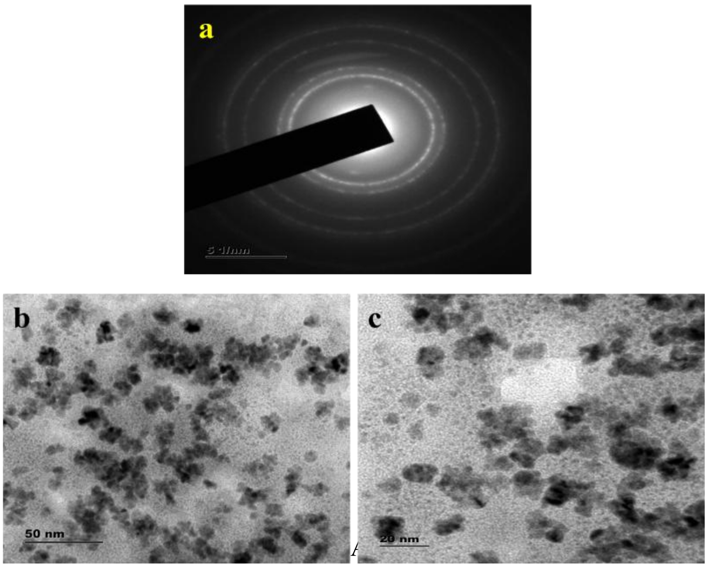


Figure 5. Characterization of SeNPs (a) Energy-dispersive spectroscopy analysis and (b) & (c) Field emission scanning electron microscopy analysis in different magnification.

Field emission scanning electron microscopy images of green synthesized selenium nanoparticles are shown in the figure.5 (b-c). Morphology of the green synthesized selenium nanoparticles was spherical and the average particle size was 25 nm. The EDAX spectra of green synthesized selenium nanoparticles confirmed that Se was the major element, with ~3-keV signal. Moreover, the presence of a sharp optical absorption peak in the range of 2 to 3 keV was typical for the absorption of metallic selenium nano-crystallites.



HR-TEM analysis showed the different sizes of SeNPs due to the bio reduction of selenium oxide by the aqueous extract. Mostly, the biosynthesized SeNPs were spherical. The size of the SeNPs ranged between 23.9 and 57.1 nm. The results of SAED confirmed that the biosynthesized SeNPs were spherical with an fcc phase. The observed rings corresponded to the (111), (200), (220), and (311) planes of the fcc crystalline lattice of SeNPS (Figure 6). In nanotechnology, selenium nanoparticles, or Se-NPs, are highly sought-after materials. Because there is an increasing need for low-cost, non-toxic, ecologically acceptable technologies, "green" synthesis offers unique benefits. The antimicrobial, antiviral, anticancer, antioxidant, anti-inflammatory, and other features of selenium nanoparticles—as well as the mechanisms underlying these processes—as well as current knowledge and methods regarding their potential biomedical application are discussed (Mikhailova, 2023). Moreover, plant-derived Se-NPs have noteworthy antimicrobial characteristics and hold great promise for use as sensory probes, therapeutic drug delivery, anticancer agents, and heavy metal detectors (Khalilov, 2023; Ikram *et al*., 2021; Cittrarasu *et al*., 2021). The fast conversion of selenium ions to SeNPs is caused by reducing water-soluble phytochemicals like flavones, tannins, quinones and organic acids (Ghaffari-Moghaddam *et al*.,2014). It was in the present study *Pontendria crassipes*- selenium nanoparticles were synthesized and characterized using various techniques, including Ultraviolet-visible spectroscopy (UV), Fourier-transform infrared spectroscopy (FT-IR), Scanning electron microscope (SEM), Dynamic Light Scattering (DLS), Zeta Potential (ZP), X-ray diffraction (XRD) and Transmission Electron Microscopy (TEM)

CONCLUSION

Biogenic synthesis of selenium nanoparticles is successful since the biomolecules used in the reduction process are derived from plants and are thus entirely non-toxic to the environment. The evaluation of green produced selenium nanoparticles against the extract of *Pontederia crassipes* can be encouraging results in the realm of nanotechnology for mosquito control and environmental sustainability. The manufacture and application of selenium nanoparticles was examined with an emphasis on their potential efficaciousness as mosquito larvicides. To sum up, the use of *Pontederia crassipes* extract in the characterization of green manufactured selenium nanoparticles offers a viable approach to battle *Aedes aegypti* mosquitoes. The integration of plant extracts with nanoparticles has emerged as a promising approach for controlling target species. This innovative method leverages the bioactive compounds present in plant extracts such as saponin, Terpenoid's and alkaloids which enhances their efficacy through nanoparticle mediated delivery. In order to increase the production and efficacy of the nanoparticles, further studies may be conducted on the synthesis parameters, the effect the nanoparticles on species other than the target species, specify and validating the potential of this innovative approach.

ACKNOWLEDGMENT

The authors are thankful to Dr. Litty Koria, Head and Associate professor, PG & Research Department of Zoology, L.R.G. Govt Arts College for Women, Tiruppur, Tamil Nadu. India

CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

FUNDING

This study received no specific funding from public, commercial, or not-for-profit funding agencies.

AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

REFERENCES

Mikhailova, E. O. (2023). Selenium nanoparticles: Green synthesis and biomedical application. *Molecules, 28*(8125). https://doi.org/10.3390/molecules28248125

Mushtaq, M. M., Peerzada, S., & Ishtiaq, S. (2021). Pharmacognostic features, preliminary phytochemical screening and *in vitro* antioxidant studies of indigenous plant of Lahore. *International Journal of Advanced Biological and Biomedical Research, 9*(2), 190–201.

Zhang, W., Chen, Z., Liu, H., Zhang, L., Gao, P., & Li, D. (2011). Biosynthesis and structural characteristics of selenium nanoparticles by *Pseudomonas alcaliphila*. *Colloids and Surfaces B: Biointerfaces, 88*(1), 196–202.

Fernández-Llamosas, H., Castro, L., Blázquez, M. L., Díaz, E., & Carmona, M. (2017). Speeding up bioproduction of selenium nanoparticles by using *Vibrio natriegens* as microbial factory. *Scientific Reports, 7,* 16046. https://doi.org/10.1038/s41598-017-16378-1

Winkel, L. H. E., Johnson, C. A., Lenz, M., Grundl, T., Leupin, O. X., Amini, M., & Charlet, L. (2012). Environmental selenium research: From microscopic processes to global understanding. *Environmental Science & Technology, 46*(2), 571–579.

Sharma, G., Sharma, A., Bhavesh, R., Park, J., Ganbold, B., Nam, J. S., & Lee, S.-S. (2014). Biomolecule-mediated synthesis of selenium nanoparticles using dried *Vitis vinifera* (raisin) extract. *Molecules, 19*(3), 2761–2770.

Semu, J., Williams, B., Cheng, J., Mutingwende, I., & Chifamba, J. (2024). *Pontederia crassipes* biosynthesised silver nanoparticles (AgNPs), characterisation and activity against multidrug-resistant microbes. *Journal of Advances in Medical and Pharmaceutical Sciences, 26*(6), 1–16. https://doi.org/10.9734/jamps/2024/v26i651305

Harun, I., Pushiri, H., Amirul-Aiman, A. J., & Zulkeflee, Z. (2021). Invasive water hyacinth: Ecology, impacts and prospects for the rural economy. *Plants, 10,* 1613. https://doi.org/10.3390/plants10081613

Pålsson, K., & Jaenson, T. G. T. (1999). Plant products used as mosquito repellents in Guinea Bissau, West Africa. *Acta Tropica, 72,* 39–52.

Ghosh, A., Chowdhury, N., & Chandra, G. (2012). Plant extracts as potential mosquito larvicides. *The Indian Journal of Medical Research, 135,* 581–598.

Kalita, B., Bora, S., & Sharma, A. K. (2013). Plant essential oils as mosquito repellent: A review. *International Journal of Research and Development in Pharmacy and Life Sciences, 3,* 715–721.

Lupi, E., Hatz, C., & Schlagenhauf, P. (2013). The efficacy of repellents against *Aedes, Anopheles, Culex* and *Ixodes* spp. – A literature review. *Travel Medicine and Infectious Disease, 11,* 374–411.

Rehman, J. U., Ali, A., & Khan, I. A. (2014). Plant-based products: Use and development as repellents against mosquitoes: A review. *Fitoterapia, 95,* 65–74.

Shaalan, E. A., & Canyon, D. V. (2015). A review on mosquitocidal activity of botanical seed derivatives. *Current Bioactive Compounds, 11,* 78–90.

Tehri, K., & Singh, N. (2015). The role of botanicals as green pesticides in integrated mosquito management: A review. *International Journal of Mosquito Research, 2,* 18–23.

Naseem, S., Malik, M. F., & Munir, T. (2016). Mosquito management: A review. *Journal of Entomology and Zoology Studies, 4,* 73–79.

Remia, K. M., Logaswamy, S., & Shanmugapriyan, R. (2017). Efficacy of botanical repellents against *Aedes aegypti*. *International Journal of Mosquito Research, 4,* 126–129.

Hikal, W. M., Baeshen, R. S., & Said-Al Ahl, H. A. H. (2017). Botanical insecticide as simple extractives for pest control. *Cogent Biology, 3,* 1404274.

Bekele, D. (2018). Review on insecticidal and repellent activity of plant products for malaria mosquito control. *Biomedical Research and Reviews, 2*(2), 2–7.

Gharsan, F. N. (2019). A review of the bioactivity of plant products against *Aedes aegypti* (Diptera: Culicidae). *Journal of Entomological Science, 54,* 256–274.

Noronha, M., Pawar, V., Prajapati, A., & Subramanian, R. B. (2020). A literature review on traditional herbal medicines for malaria. *South African Journal of Botany, 128,* 292–303.

Ganesan, P., Samuel, R., Mutheeswaran, S., Pandikumar, P., Reegan, A. D., et al. (2023). Phytocompounds for mosquito larvicidal activity and their modes of action: A review. *South African Journal of Botany, 152,* 19–49.

Senthi-Nathan. (2020). A review of resistance mechanisms of synthetic insecticides and botanicals, phytochemicals and essential oils as alternative larvicidal agents against mosquitoes. *Section Invertebrate Physiology,* 10–2019.

Vetrivel, C., et al. (2019). Fabrication and characterization of noble crystalline silver nanoparticles from *Ceropegia bulbosa* Roxb root tuber extract for antibacterial, larvicidal and histopathology applications. *Nanosci. Nanotechnology. Letter, 11,* 11–21.

Khalilov, R. (2023). A comprehensive review of advanced nanobiomaterials in regenerative medicine and drug delivery. *Advances in Biology and Earth Sciences, 8*(1), 5–18.

Cittrarasu, V., Kaliannan, D., Dharman, K., Maluventhen, V., Easwaran, M., Liu, W. C., & Arumugam, M. (2021). Green synthesis of selenium nanoparticles mediated from *Ceropegia bulbosa* Roxb extract and its cytotoxicity, antimicrobial, mosquitocidal and photocatalytic activities. *Scientific Reports, 11*(1), 103. https://doi.org/10.1038/s41598-020-79317-8

Ghaffari-Moghaddam, M., Hadi-Dabanlou, R., Khajeh, M., Rakhshanipour, M., & Shameli, K. (2014). Green synthesis of silver nanoparticles using plant extracts. *Korean Journal of Chemical Engineering, 31*(4), 548–557.