

## SUMMARY AND CONCLUSION

In this research work, synthesis of metallic and non-metallic nanoparticles using plant extracts, cereals and pulses washed water, and free edge of human nails are carried out. The pharmacological, biological, cosmetic and sensing applications of synthesized nanoparticles were delved in this study. Owing to sustainable and green synthesis, toxic chemicals or reaction routes are avoided in this study. Thus, plant extracts, washed waters of cereals and pulses were utilized for the synthesis of metallic and non-metallic nanoparticles. The synthesized nanoparticles were tested for their efficiency for anti-bacterial agents, anti-cancer agents, sensory probe for detecting toxic chemicals and active ingredient in sun screen lotion formulations.

The systematic review helps to understand the prior art in this field of study. After the careful observation of the previous reports, *Terminalia bellirica* fruit parts, *Garcinia cambogia* capsules, cereals and pulses (Indian, Indonesian, Thailand, Boston) washed water and free edges of *Corpus unguis* are utilized in this research. From the literature review it was understood that, utilizing the mentioned reducing agents GNP, SNP, ZnONP and reduced graphene oxides are not synthesized and their properties are not explored.

The brief summary and conclusion drawn from the this study is detailed below:

- ❖ The determination of phytochemicals in the plant extracts, the nutrient analysis and elemental composition of cereals/pulses washed water and *Corpus unguis*, helps to understand the active components in the bioreductants which is being utilized for the reduction of metal ions and graphene oxide for the synthesis of metallic nanoparticles and reduced graphene oxide respectively. These active constituents in the bioreductants are responsible for the rapid formation of the nanoparticles, the particle size, and shape of the nanoparticle and the potential characteristics of the metallic nanoparticles and reduced graphene oxide particles.

- ❖ For the synthesis of GNPs using the reducing agents, various methods were employed. TB fruit parts aided GNP was synthesized by room temperature method. Instant synthesis of GNP was observed within seconds.
- ❖ HN28 aided GNP was synthesized via sunlight method and within minutes GNP formation was ensured.
- ❖ Cereals and pulses washed water aided GNP was optimized by four different methods, RT, sonication, sun light irradiation and microwave heating. Among the methods adopted, the GNP formation was fast with microwave heating of the Au salt solution and the cereals and pulses washed water. More time required in RT. In all the methods GNP was formed.
- ❖ In microwave oven method, all the samples require less time to reduce Au ions. IBrRW require only 30s for all the concentration for the formation of GNPs. Compared to other methods TDWW sample requires only 90s-145s for the formation of GNPs.
- ❖ As microwave oven method requires less time for the formation of GNPs, GC was used to reduce Au ions by microwave oven heating method. Foreign rice varieties, Indonesian rice washed water; InB and InW requires only 40s – 1min 30s for the formation of GNPs. ThW and BoW samples require more time to reduce Au ions.
- ❖ The SNPs formation was ensured with the TB fruit parts and cereals and pulses washed water by solar irradiation method. The SNPs were formed instantaneously by solar irradiation method.
- ❖ There are no past reports on the utilization of cereals and pulses washed water for the synthesis of nanoparticle. The cereals and pulses washed water from Indian varieties and rice varieties from Thailand, Indonesia, and Boston were utilized to analyze their capability and efficiency to reduce Au ions to form GNP. Among the method of synthesis domestic microwave oven method was found to be an effective method which forms GNPs within seconds. RT method requires more time for the formation of GNPs. All the samples are capable of reducing Au into GNP. The nutrients and elements present in the samples helps to better stabilization and formation of GNPs.
- ❖ The nutrients present in the cereals and pulses washed water such as carbohydrates, fats and Vitamin B6 act as reducing agents. Synergistic effect of all the components in the washed water helps for the rapid reduction of  $ZnSO_4$  into ZnONP.
- ❖ The refluxing method was found to be efficient in the conversion of GO to RGO by cereals and pulses washed water as reducing agents.

- ❖ Analytical characterization methods were carried out to determine the structure, surface morphology of the synthesized GNP, SNP, ZnONP.
- ❖ The SPR of GNP lies in 520-580nm, SNP in 420-490nm and ZnONP between 320-370nm ensures the formation of the nanoparticles.
- ❖ The crystalline natures of nanoparticles were observed from XRD analysis.
- ❖ The size and surface morphology of the nanoparticles were ensured from FE-SEM analysis. Almost all the SNP and GNP were observed to be spherical in shape. The size of the nanoparticles was found to be in the range of 5nm to 70nm.
- ❖ The zeta potential analysis of GNP and SNP ensured the stability of the nanoparticles.
- ❖ The TGA analysis of the ZnONP ensures the thermal stability of the nanoparticles. The synthesized ZnONP were found to be stable upto 1000°C.
- ❖ The efficiency of cereals and pulses (Indian varieties) washed water in reducing GO by reflux heating method.
- ❖ All the cereals and pulses washed water were found to be efficient in reducing GO to RGO, the change in colour of the mixture to black ensure the formation of RGO.
- ❖ The FTIR, Raman spectra ensures the elimination of oxygen functional group from the surface of GO.
- ❖ The TGA analysis ensured the thermal stability and decomposition nature of the RGO. Among the synthesized RGOs, BJWWRGO and BuWWRGO are stable and less mass loss upto 1000°C.
- ❖ The TBOSGNP and TBPGNP were efficient against *A.pneumonia*, *B.subtilis*, and *E. faecalis* clinically isolated pathogens. It is observed that spherical shaped particles shows better anti-bacterial activity.
- ❖ TB aided SNP shows selective inhibition against clinically isolated *Staphylococcus aureus*. Among the SNPs, TBOSSNP have good zone of inhibition. This sample was coated over an ear phone buds and found to be anti-bacterial.
- ❖ The cereals and pulses washed water aided SNP and GNP were found to be efficient against *Klebsiella pneumoniae*, *Bacillus cereus*, *Staphylococcus aureus* and *Escherichia coli* than cereals and pulses washed water. IBoRWSOAg, BJSOAg, IBRRWAgSo and WCAgSo are equally efficient in inhibition of *K. pneumoniae*. The ZOI is 13mm and on par with the standard ciprofloxacin (100ng/mL) used in this study. *B. cereus* inhibition is better with WCAgSo (ZOI- 15mm).

- ❖ IBoRWSOAg gives a better inhibition against *S. aureus* than other samples with zone of inhibition 19mm which is very much closer to the value of standard drug (20mm). BJWM, BJAgsO, IBRRAgSo samples are efficient in inhibiting *E.coli* with ZOI 17mm. Comparing SNP and GNP, SNPs has better ZOI values compared to GNPs. This might be due to the presence of Ag in the particles.
- ❖ The GNP and SNP were found to be good anti-skin cancer agents against A375 cell lines. Compared to SNP and GNP, GNP's are efficient against A375 cell lines. The synergistic effect of Vitamin B6, carbohydrate and proteins along with Au particles in IBRRWM, WCWM and BJWM have inhibited the growth of A375 cell lines. A biocompatible solution is obtained by the efficiency of cereals and pulses washed water aided SNP and GNP against the growth of A375 cell lines.
- ❖ DNA binding studies ensures that the GNPs and SNPs are good intercalators. The study also ensures that the samples are not genotoxic.
- ❖ The *Allium cepa* root tip toxicity assay ensured that the BJWM is not toxic to the plant cells.
- ❖ Lotion formulation incorporating HN28 and RaZn showed photo protective activity, occlusivity and they are good anti-microbial agents against skin infection causing microbes.
- ❖ Among the samples RWZnCND shows best SPF 18. The *in vitro* occlusivity test revealed good occlusivity factor compared to vaseline, chosen as standard for this present study. The results imply that the RWZnCND can be used as a good moisturizer.
- ❖ It was observed that RWZnCND has highest SPF (18) compared to other prepared formulations. The synergetic effect of RaZn, IRaRW and *Cynodon dactylon* extract might have helped to increase the photo protective activity.
- ❖ TBPGNP can be attributed as a self-powered nano switch towards sensing ammonia. The surface stabilized TBPGNP by secondary metabolites such as alkaloids, flavonoids, sterols and tannins present in the TBP extract might have modified the surface and helps to sense ammonia gas.
- ❖ The selective detection of  $\text{CN}^-$  ions by GCAu was accomplished. The selectivity of the gold nanoparticles to detect  $\text{CN}^-$  is witnessed as it does not show any colour change when mixed with different reagents.
- ❖ Melamines leached out from melamine dinnerware were determined using FT-IR fingerprinting and comet assay results shows the samples are genotoxic.