# Synthesis and Characterization of Different Forms of Cu Nanoparticles to Mitigate its Leaching to Water Bodies

## Introduction

The application of various Cu-based pesticides has resulted in increased Cu concentrations in agricultural soils. Although Cu is an effective biocide, it may also affect non-target organisms and could pose environmental concerns. High Cu concentrations in soils were reported to have adverse effects on soil biota and plants. Additionally, Cu may be washed into the aquatic environment from agricultural and urban application locations and may also enter aquatic environments when Cu is used as a biocide in antifouling paint formulations. As such, contaminated soils with increased levels of Cu pose a risk for surface water and groundwater qualities as well as a threat to aquatic organisms. Furthermore, it may also affect the performance of biological water and wastewater treatment facilities. In recent years, applications of Cu-based pesticides have extended the use of bulk and ionic forms into Cu-based micro-and/or-nano-particles such as Cu, $Cu_2O$, CuO, and $CuCO_3$ nanoparticles. This great demand has been largely due to the wide range of unique physicochemical and biocidal/biostatic properties of these materials at the nanoscale. In general, Cu-based nanoparticles have been used in fungicides, wood preservation, and agricultural pesticide applications. Some research suggests that nano Cu toxicity depends on particle size. It has been reported that there is a 15 to 65-fold increase in toxicity when nanosized Cu particles are used in relation to bulk Cu. In most studies, the increase in Cu-based NPs toxicity is attributed to, among other things, an increase in solubility and ion release and, consequently, bioavailability. Therefore, it is the duty and responsibility of the research community to synthesize a less leaching Cu-based nanoparticles for various applications.

## The goal and Objective of the Research

The goal of this research is to open the realm of the multidisciplinary field of nanotechnology to the teachers by synthesizing different forms of Cu-based nanoparticles that mitigate its leaching to the environment. It will empower them with integrated knowledge to solve inter-related and consequential environmental problems. It will be attractive to students and teachers who tend to choose a career pathway that could potentially improve the quality of the environment. Teachers who participate in this project will have the capacity and chance to train new teachers and students at their schools depending on the resources available to them. This kind of activity exposes students to problems faced by environmental engineers as they develop new materials or technology to improve the quality of the environment.

The main objective of the research is to synthesize and characterize different forms of Cu-based nanoparticles to mitigate its leaching to the environment. The specific objectives are:

- to understand the impact of different concentrations of Cu salts, PVA, and electrolyte salts on the size and stability of the synthesized nanoparticles,
- to determine the impact of environmental parameters such as pH, ionic strength, and humic acids on the leaching of ionic copper, and
- to analyze the photocatalytic activity of the synthesized nanoparticles for the degradation of non-degradable organic wastes.

## Research Methods and Materials

Participant teachers will synthesize different forms of Cu and polyvinyl alcohol (PVA) nanocomposites. In the synthesis process $CuSO_4$/ $CuCl_2$/ $Cu(NO_3)_2$ as Cu precursors, $NaBH_4$ as reducing agent, $NaHCO_3$/ $Na_2CO_3$/ NaOH/ NaI/ NaBr as electrolyte salts, and PVA as stabilizing/

compositing agent will be used. Bench lab pump and stir plate/bars will be used to deliver and mix the reactant chemicals, respectively. The effect of temperature (analog heat and stir plate) on the synthesized nanoparticles will be investigated. The hydrodynamic diameter and zeta potential, the morphology, and the absorbance and wavelength of the synthesized nanoparticles will be determined using dynamic light scattering (DLS), tunneling electron microscopy (TEM), and UV-Vis spectroscopy techniques, respectively. The leaching (ionic portions) of the synthesized particles at different pH (5, 7, and 9), ionic strength (1, 10, and 100 mM of $NaNO_3$ and $Ca(NO_3)_2$) and humic acids (5, 20, and 100 mg $L^{-1}$) values will be evaluated by centrifugal ultrafiltration process using Amicon ultrafiltration tubes. The concentrations of the leachates will be analyzed using UV-Vis and/or atomic absorption spectroscopy techniques. The degradation of methylene blue which is one of the non-degradable wastes from textile or other industries will be evaluated by the synthesized nanoparticles under solar energy and dark conditions as a function of time (0, 0.5, 1, 1.5, and 2 hours). Solar energy source apparatus and cells will be used. The concentration of the methylene blue will be determined using UV-Vis spectroscopy.