Chapter 2

Aim and Scope
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Every aspect of human activity are closely connected with the natural environment. The rapid development of technology, especially at the end of 20\textsuperscript{th} century, has enormously increased man's ability to produce goods, which intern, have enhanced his standard of living. On the other hand, this development has also generated a secondary phenomenon, the environmental pollution. Such effect led to a deterioration of life quality. Thus, improvement of the life quality owing to innovative technologies caused negative effects on the environment. In order to keep the balance between technological development and main components of the human environment, the appropriate technologies should be used which appears to be a powerful force for the improvement of the environment.

Groundwater and superficial water have been contaminated in various ways like mining waste including cyanide and heavy metals, agricultural chemicals, industrial and domestic sewage. Pollution by heavy metals is a serious threat to aquatic ecosystem because of their potential toxicity, even at low concentrations. Additionally heavy metals are not biodegradable and tend to accumulate in living organisms.

Wastewater treatment facilities have been improved over the years in many countries, eventhough water pollution remains a problem, including in industrialized countries.
Among the various methods, adsorption technology was found to be the most effective method for the remediation of water. As follows from the above considerations, the subject of utility of modern adsorption technologies has enormous environmental and economical importance and constitutes a serious challenge with the prospects for further intense development.

Over the past few decades, adsorption technology has developed from a relatively minor process to a major unit operation, with adsorption processes in widespread use in the petroleum and petrochemical industries and in the production of industrial gases as well as in more traditional applications such as air and water purification. The growing importance of adsorption (e.g. in separation technology, industrial catalysis and pollution control) has resulted in the appearance of an ever increasing volume of scientific and technical literature on novel adsorbents and catalysts. Also, various new procedures have been introduced over the past few years for the interpretation of adsorption data.

Activated carbons are versatile adsorbents and its adsorptive properties are due to high surface area, a microporous structure and a high degree of surface reactivity. The activated carbon is used to purify, decolorize, deodorize, dechlorinate, separate, and concentrate in order to permit recovery and to filter or remove the harmful constituents from liquid solutions. Consequently, adsorption using activated carbon is of interest to many economic sectors and concerned areas as diverse as food, pharmaceutical, chemical, petroleum, nuclear, automobile, and vacuum industries as well as for the treatment of drinking water, industrial and urban wastewater.
A huge research has been carried out in the area of activated carbon adsorption during the past few decades, and research data are scattered in different science and technology journals. The high cost of activated carbon used for the treatment of wastewater has led the researchers to look for newer, more effective and economically low cost adsorbents. In this regard researchers from all over the world are continuously exploring a numerous kinds of materials which ranges from microorganisms to industrial byproducts.

Nanoparticles are expected to play a crucial role in water purification. The environmental fate and toxicity of a material are the critical issues in material selection and design for water purification. Nanoscience and technology has emerged as a frontier area of research today. A great deal of stimulating progress is being made in the world of nanoscience every day. Research in “Nanochemistry,” has resulted in the developments of newer methods for the synthesis of materials with desired structure, composition, and properties and their related applications.

Advances in nanoscale science and engineering suggest that many of the current problems involving water quality could be resolved or greatly diminished by using nanoadsorbents, nanocatalysts, bioactive nanoparticles, magnetic nanoparticles, nanoclusters and nanocolloids, although research in the area of heavy metals removal by nanomaterials is also underway.

This thesis comprises the results obtained during detailed investigations on the remediation and analysis of heavy metal ions from aqueous wastewater. The metal oxide nanoparticles ZnO, NiO, CuO and their hydroxides (Zn(OH)₂, Ni(OH)₂ and Cu(OH)₂) were synthesized via precipitation method, which is one of the cost effective methods. The effect of metal ion concentration and calcination temperature
for the preparation of nano metaloxides was studied. The influence of capping agents on the orientation of nano particles was analyzed.

The synthesized metal oxide and hydroxide nanoparticles were used as adsorbents for the removal of potentially toxic heavy metal ions such as Hg(II), Pb(II), Cd(II), Cr(VI), Zn(II) and Cu(II) from aqueous wastewater. These metal oxide nanoparticulates exhibit good reactivity towards the adsorption of heavy metal ions from wastewater. The batch mode of adsorption was employed to study the process of adsorption of these metal ions. The dependence of adsorption capacity on pH, time, and temperature was evaluated for all the metal oxide nanoparticles.

The differential pulse stripping voltammetry was used for the analysis of metal ions before and after adsorption process. This electroanalytical tool has proved to be a powerful analytical artistic execution for the analysis of heavy metal ions at low concentrations. The mass balance equation was used to calculate the adsorption capacity of the adsorbents and fitted with the isotherm, kinetic and thermodynamic models.

The ZnO, NiO and CuO nanoparticles were also used for the modification of carbon paste electrodes for the determination of Pb(II), Cd(II) and Hg(II) ions from aqueous solutions using differential pulse stripping voltammetry. The effect of pre-deposition conditions on the sensitivity of the modified electrode was optimized and the detection limit was calculated.

Further barium hydrogen phosphate (BHP) and strontium hydrogen phosphates (SHP) were synthesized and used for the modification of carbon paste electrode. Thus prepared electrodes were employed for the detection of heavy metal ions, which shows good precession without the interference of other metal ions.
The prepared ZnO, NiO and CuO nanoparticles show good adsorption capacity for heavy metal ions. The NiO has got greater adsorption capacity than ZnO and CuO nanoparticles. In addition, the BHP modified carbon paste electrode exhibited good sensitivity and catalytic activity for the determination of heavy metal ions from aqueous solutions when compared to ZnO, CuO, NiO and SHP modified electrodes.