



# Competitive adsorption of lead and zinc from aqueous solution on activated carbon prepared from Van apple pulp: Study in single- and multi-solute systems

Tolga Depci<sup>a,\*</sup>, Ali Rıza Kul<sup>b</sup>, Yunus Önal<sup>c</sup>

<sup>a</sup> Yuzuncu Yil University, Faculty of Engineering – Architecture, Department of Mining Engineering, 65080 Van, Turkey

<sup>b</sup> Yuzuncu Yil University, Faculty of Arts and Science, Department of Chemistry, 6580 Van, Turkey

<sup>c</sup> Inonu University, Faculty of Engineering, Department of Chemical Engineering, Malatya, Turkey

## HIGHLIGHTS

- ▶ Adsorption is an effective process for removing lead and zinc from aqueous solution.
- ▶ Activated carbon was prepared from apple pulp by chemical activation with ZnCl<sub>2</sub>.
- ▶ The properties of prepared carbon were determined by BET, XRD, SEM, FTIR and zeta potential.
- ▶ Lead and zinc were removed effectively from single- and multi metal aqueous solution by the activated carbon.

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## ABSTRACT

The potential of activated carbon (VAAC) prepared from local agricultural waste, apple pulp, as an alternative low-cost adsorbent was investigated for the removal of lead and zinc from single- and multi metal aqueous solution. VAAC was produced with a reasonable yield, 43% and has remarkable surface area (1067.01 m<sup>2</sup>/g) with a well-developed pore structure. To determine the adsorption process and properties, the effects of various operating parameters, pH of the solutions (2–6), adsorbent dosage (0.01–0.2 g), initial concentration of metal ions (25–40 mg/L), contact time (3–120 min) and temperature (298–308 K) were investigated in a batch adsorption technique. The adsorption isotherm data were better fitted by Langmuir model. The pseudo second-order model was found more applicable to describe the kinetic of system in both the single- and multi-solute system. The adsorption capacities of heavy metals decrease in the order of Pb(II) (15.96 mg/g) < Pb (Pb + Zn) (13.23 mg/g) < Zn(II) (11.72 mg/g) < Zn (Pb + Zn) (7.54 mg/g) at 298 K. Although individual metal ions adsorption decreases in multi-system, the more metal ions are adsorbed (20.77 mg/g). The intraparticle diffusion model, external mass transfer coefficient, film and pore diffusion coefficient at different temperatures were also evaluated to investigate the adsorption mechanisms of both systems. The adsorption was mainly controlled film diffusion process at all operating temperatures and concentrations. The thermodynamic parameters indicate that the adsorption process is endothermic, feasible and thermodynamically favored.

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## 1. Introduction

Lake Van Basin (Turkey) has potential metallic mine reserves (Au, Cu, Pb, Zn, Cr, Mn, Ni) due to its geological structure and ancient volcanic activities. Some of these mines were produced by ancient Anatolian civilizations like Urartians and this basin was one of the most significant areas of that era [1]. Recently, lead and zinc have been produced in small scale in Pb–Zn mining area and researches aiming to find their new potential reserves have still been continuing in Bahçesaray in Van province (Turkey).

Lead and zinc are the most utilized important heavy metals and used many industrial branches in large amounts. However, they are well-known toxics and can find their ways to the aquatic environment through wastewater discharge. Finally, they may cause in severe heavy metal contamination of the Lake Van, the fourth-largest closed lake on earth, which is the final drainage area in the basin.

The maximum acceptable limit of lead and zinc in potable water is 0.1–0.05 mg/L [2] and 5.0 mg/L [3], respectively. These heavy metals are not biodegradable and tend to accumulate in living organisms directly or indirectly causing various diseases and disorders such as anemia, malaise, liver and kidney diseases, apathy, infertility and abnormalities in pregnant women, brain damage

\* Corresponding author. Tel.: +90 432 225 10 24; fax: +90 432 225 17 32.

E-mail address: [tdepce@gmail.com](mailto:tdepce@gmail.com) (T. Depci).