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# Comparison of the Effectiveness of Biological and Chemical Leaching of Copper, Nickel and Zinc from Circuit Boards

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**ABSTRACT**

The progress of civilization brings with it the development of advanced technologies and increased demand for electric and electronic equipment. That directly influences the increase of produced e-waste, called Waste of Electrical and Electronic Equipment (WEEE). Due to the fact that deficit and critical metals are running out throughout the World, and due to increased demand for those metals, their alternative source and recovery methods have to be found. As an alternative biotechnological methods can be used. The advantage of biological methods over chemical processes is its selectivity in regard to different metal groups, simplicity of technological process, economic effectivity (lower energy expenditure) and lack of negative impact on environment. The aim of this work was to compare the effectiveness of biological and chemical leaching of copper (Cu), nickel (Ni) and zinc (Zn) from circuit boards (PCBs).The experiment was conducted in variants which included factors such as temperature (24°C and 37°C) and speed of mixing. In case of all metals higher effectiveness was achieved in variants conducted in the temperature of 24°C and faster mixing than in temperature of 37°C and slower mixing. In case of cooper and zinc better results of metal removal were achieved in bioleaching variant. In case of nickel faster result of metal removal were achieved in chemical leaching, but at the end of the experiment the effectivity of chemical leaching and biological leaching was similar. The maximum efficiency of cooper, nickel and zinc release was adequately 100%, 90%, 65%.

**Keywords:** bioleaching, chemical leaching, e-wastes, PCBs, heavy metals

## INTRODUCTION

The progress of civilization brings about the development of advanced technologies and increased demand for electric and electronic equipment. That directly influences the increase of the produced e-waste, called Waste of Electrical and Electronic Equipment (WEEE). It is estimated that currently 48% of households have a computer. Worldwide, 44.7 million tons of electronic waste was produced in 2016. The greatest amount of electronic waste was produced in Asia (18.2 million tons), followed by Europe (12.3 million tons), then both Americas (11.3 million tons), Africa (2.2 million tons) and Oceania (0.7 million tons). It is predicted that this amount will rise to 52.2 million tons until 2021, with a yearly gain of 3 to 4% [2,7]. WEEE is one of the fastest growing waste streams worldwide and it is estimated that it currently constitutes around 8% of municipal waste stream [7, 20]. Unfortunately, in 2016 only 20% of the produced WEEE was collected and recycled. About 80% of the e-waste is not covered by statistics and only 41 countries are collecting this data. At present, Europe recycles 35% of its WEEE which is the greatest amount in the world. Both Americas collect only 17% of produced e-waste, Asia – 15%, and Africa has documented less than 1% of collected and recycled WEEE [2]. An unfavorable tendency to export the e-waste from wealthy countries to developing regions has existed for years now, frequently under the pretext of helping the poorest regions of the world. In those countries, recycling precious metals is carried out using amateur methods without using any technology, frequently without care for the