ABSTRACT

Environmental, as well as economic considerations, play a significant role in the utilization of waste materials like fly ash and copper tailings. Utilization of fly ash will reduce disposal costs while increasing revenues through the sale of fly ash. The fly ash used in combination with copper tailings can reduce greenhouse gas emission by replacing other alkaline materials such as cement/lime, which used for solidification to prevent leaching and contributes pollutants to surroundings during their production. These materials have been used successfully for other purposes such as in concrete or road pavements, then the overall problem of waste disposal can be reduced considerably. Hence this site-specific study is undertaken to assess the reduction in leaching of various metals from both these wastes and to evaluate the potential of combined utilization of both fly ash and copper tailings for the purposes such that the waste disposal problem is minimized.

The seriousness of the threats posed by the heavy metals leaching from both FA and CT by way of their disposal has initiated a series of research initiatives. One solution is to convert these wastes into an insoluble and harmless form as much as possible to prevent their re-entry into the environment. They can also be converted to different products which are economical and sustainable.

Outstanding works have been done by eminent researches to assess the impact on surroundings due to FA and CT. It was observed that the disposal, transportation, and storage of FA lead to affect the surrounding soil, surface, and groundwater adversely. The calcium-rich FA can be used to manage acid generation in mine tailings, due to its inherent mineralogy and binding nature. Many researchers have investigated how the chemical composition, fine particle size, ample reserves, and pozzolanic ingredients make it suitable for the various application and valorization of this abundant waste. A considerable amount, 128 tons of waste tailings is generated to produce one tone of pure copper, which leads to impact the surrounding environment severely. Some effort is done in the utilization potential of copper tailing in different areas. However, as the demand for copper increasing exponentially due to its versatile uses more core investigation is needed in this regard.

An abundant amount of copper tailings and fly ash is spread all over without having any kind of lining and separation from the surrounding. This improper handling of waste will lead to a possible adverse impact on the surroundings. The mineralogy and elemental analysis result, along with SEM images, gives a fair idea of the constituents and possible threat on the environment. Different leaching studies were conducted in this regard to assess possible hazard to the surrounding environment. ASTM & TCLP batch leaching of the combination of both FA and CT exhibits a higher concentration of As and Mn if the CT concentration is high. Regression analysis of bath leaching tests shows a positive correlation between pH and Co, Cu, Fe, Mg, and Mn. FA to CT ratio is negatively correlated with pH. The groundwater sample near the waste disposal sites was collected and analyzed to find out the concentration of heavy metals.

LCA process is used to evaluate the said ill effect on the environment. Its results enable authorities to understand the possible environmental related changes. LCA is a step by step scientific approach to quantify the overall environmental impact assessment of process/product from its production to utilization and disposal. This method is very diverse, and the reliability and accuracy are majorly depended on the accuracy of the input and output life cycle inventories (LCI). Utilization potential of both FA and CT in concrete as a partial replacement of cement is attempted. Before the strength test, a detailed LCA analysis is performed. The midpoint and endpoint used for the LCA analysis, are discussed with regards to concrete. Different approaches followed in LCA analysis viz. cradle to gate, cradle to grave, and cradle to cradle are presented. Researchers have suggested the cradle to the grave approach more appropriate for the analysis of concrete. A model is developed for the LCA assessment of different modified concrete mix proportions using UMBERTO NXT tool. It shows the detailed environmental impact of the FA and CT utilization in concrete. The cause-effect part of the model which has been assessed by different midpoint factors, has been presented. The results of LCA are analyzed and compared with control mix proportions. Final endpoint factors, shown the overall effect in terms of eco-system quality, human health, and resource availability, are presented, and their values are compared. All the results of LCA analysis show that the modified concrete mix affects comparatively less in all midpoint factors and endpoint factors. Economic feasibility of this utilization has also been assessed. The results of economic analysis show a significant decrease in the production cost of the modified concrete mix proportion.

The positive results of LCA and economic analysis encourage to perform strength tests. Different mix proportions of FA and CT are mixed with concrete according to literature and code provisions. The results reveal that up to a certain limit, till the extra release lime came from the cement hydration processes is available to react with the pozzolanic FA and CT, it is beneficial to add both as a replacement of cement without compromising the strength of the concrete. The results of unconfined compressive strength tests of the modified concrete have been found very encouraging. Except for a few mix samples, the modified concrete gives higher strength than the target strength.