Understanding Coal Mining Spoil Properties And Effect: A Mini Review

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Abstract

Coal is an abundant non-renewable energy resource which a major economy backup for many countries but also responsible for wastes and environmental damage. Understanding the properties of coal mine wastes (spoils) is incredibly important to minimize the effects on human health and the nearby environment and future rehabilitation measurements. The objectives of this paper are to review the physical and chemical properties of coal mine spoils (CMS) and find out the research gaps and implications. This review revealed that the removal and dumping of CMS cause heterogeneity in bulk density, water holding capacity, porosity, pH, electric conductivity (EC), soil organic matter (SOM) and cation exchange capacity (CEC) which impact acidity and salinity on nearby soil and water ecosystem. Further, this review found that there is weak empirical evidence on physiochemical properties of CMS in comparing with control sites as well as reference sites. Therefore, a comprehensive experimental data collection on coal mine spoil properties is required to provide holistic rehabilitation measures.

Keywords: Coal mine spoils; physical properties; chemical properties, acidity.

1. Introduction

The mining sector is one of the major economic backbones for several mining countries worldwide worth millions of dollars. Despite financial importance it also more substantial risks toward human health and the global environment change such as salinity, acid mine drainage and an increased risk of greenhouse gases emission throughout the life cycle of coal mining. The potential damage whether direct, indirect or cumulative caused by mines depends on the characteristics of natural resources extracted, the technology and machinery used and the surrounding environment (Kirby et al., 2010; Lechner et al., 2016; Pereira et al., 2019).

There are two ways of resource mining the surface or open cast mining and underground mining. Surface or open cut resource mining operated by the tripping-off the upper 200 meters depth of the earth surface which usually involve drill and blast and either truck and shovel or dragline. Whereas, the underground resource mining is extracting resources through an open-pit range from 200 to 600 meters deep of the earth. Surface resource mining is cheap, simple and fast but low commercial value, high waste production and high vegetation clearance compare to underground resources mining (Shrestha and Lal, 2011; Pereira et al., 2019; Feng et al., 2019).

Coal called “the Black Gold” is the most abundant non-renewable fossil fuel resource extracted thousands of years back. More than four thousand million tons of coal consumed worldwide every year which primarily use to generate electricity. Coal mining operation demands high technologies and mechanization process to achieve high-quality production and comprises of huge hazardous waste materials altering the physical and chemical properties CMS which has negative impacts on the surrounding ecosystem and promote to land and soil degradation and watercourses pollution (Gerke et al., 1998; Kirby et al., 2010; Shrestha and Lal, 2011; Uzarowicz, 2011; Park et al., 2013; Lechner et al., 2016; Wright et al., 2018; Feng et al., 2019; Ma et al., 2019; Feng et al., 2019).

Therefore, understanding the physicochemical properties of CMS is essential to deliver proper management, neutralization, and immobilization of the acidic and toxic substances to minimize their effect on soil, vegetation, and water bodies and repair the ecosystem services and productivity of these areas. This paper aims to review the physical and chemical properties of CMS and find out the research gaps and provide implications.

2. Formation, characteristics, and effects of coal mine spoil

Soil is a medium for plant growth and ecosystem service which developed by soil formation factors such as climate, organisms, topography, parent material and time. However, the anthropogenic (human being) factors such as mining inevitably accelerate soil formation. Coal mining consists of complex sequential stages from vegetation removal to the rehabilitation stage (Figure 1) (Li et al., 2014; Feng et al., 2019). CMS are formed from the continuous overburden removed of mining process comprises heterogeneous in physical and chemical properties which disrupt the rehabilitation process (Park et al., 2013; Shrestha and Lal, 2011; Lechner et al., 2016; Wright et al., 2018; Feng et al., 2019; Ma et al., 2019).

2.1 Physical properties of coal mine spoil

Soil physical properties determine the movement of air, water and nutrient through the soil play an important role in plant growth (Jat et al., 2018). However, the overburden mining operations the CMS unfavourable physical characteristics such as soil texture, bulk density, porosity, aeration and water holding capacity for plant growth.

The soil texture which determines the water holding capacity, permeability and soil workability for plant growth is affected by the high fraction of sandy loam of CMS (table 1). This reveals that CMS has high permeability, low water holding capacity and poor workability. This might affect the nutrient and water storage of the CMS. Soil bulk density and porosity reflects the size, shape and arrangement of soil particles and gives an indication of air, water and nutrient exchange capacity of the soil for plant root growth. Thus, lower bulk density (1 ds m-1 which is saline soil. This implies that poor microbial activity, poor soil structure, weak drainage, high bulk density, weak CEC. The SOC regulate the physical, chemical and biological function of soil by improving the water availability, CEC, porosity and supports the growth of the soil microorganisms. However, the SOC of the CMS is poor which implies that restrict the water availability and microorganism movement and poor CEC. Also, the richness of soil mineral depends on the CEC of the soil. As shown in Table 1, the CEC of CMS is low which indicate there is carbon deficiency in CMS which affects the water holding capacity, SOC and nutrient of the soil.

2.3 The heterogeneous characteristics effects of coal mine spoil

The operation of coal mining requires extensive removal of overburden materials results in structural and functional changes in mine spoil consist of the high level of soil compaction, poor aeration, accumulation of weatherable and un-weatherable minerals, and heavy metals which exhibit huge spatial heterogeneity on physical and chemical parameters of CMS and adverse effect on soil and land degradation, soil acidity and toxicity, polluted water bodies, nutrient depletion and the imbalance microbial activity, consequently might affect the plant growth in post-mining landscapes rehabilitation (Park et al., 2010; Shrestha and Lal, 2011; Li et al., 2014; Ma et al., 2019; Feng et al., 2019).

However, besides the physical and chemical properties understanding the availability of heavy metals concentrations on CMS very essential for the post-mining rehabilitation process. Because a vast amount of overburden containing sulphide (FeS2) bearing minerals are dumped and might be significant effect concerning oxidation and weathering processes on physical and chemical properties of CMS and the surrounding environment. As a result of sulphides containing material exposed to surface-atmosphere and encounters with water (rainfall) and air (oxygen) can lead to sulphuric acid called acid mine drainage (AMD) which alter the pH, EC, SOC and CEC of CMS, and amplified the magnitude of salt and harmful heavy metals release from these spoils to surrounding soils, vegetation and water (Feng et al 2019)

Gerke et al., (1998) reported that the sulphuric acid generated from acid mine drainage as the result of sulphide oxidation of overburden spoils at open-cast lignite mines affecting the quality of groundwater zone and surface water bodies of the Lusatian mining area in Germany. Uzarowicz, (2011) investigate that, the presence and weathering of sulphides in CMS soils cause a high risk of long-term acidification in three coal mine sites in Poland. Furthermore, a substantial acid mine drainage containing three hazardous metals Nickel (Ni), Zink (Zn) and Manganese (Mn) was identified and impact on water quality and aquatic species in Wingecarribee River, New South Wales (NSW), Australia (Wright et al., 2018).

3. Conclusion and implications

Coal called “the Black Gold” is non-renewable fossil fuel resource extracted thousands of years back as source energy and economic backbone for many countries. However, due to the complex nature of coal resource extraction is responsible for waste generation and environmental damage. Several types of research are conducted to assess the physical and chemical properties of CMS and their effect on soil and water ecosystem and the nearby environment. These studies are very crucial to reduce their impact as well as to implement proper remediation measures on CMS. This review revealed that the removal and dumping of CMS cause heterogeneity in bulk density, water holding capacity, porosity, pH, electric conductivity (EC), soil organic matter (SOM) and cation exchange capacity (CEC) which impact acidity and salinity on nearby soil and water ecosystem. Measuring, analysing and evaluation all the necessary physical properties (soil texture, bulk density, water-holding capacity, and porosity) and chemical properties (pH, EC, SOC and CEC) require to provide full information about the properties of CMS and predict their potential impact on the surrounding environment. However, this review found that there is weak empirical evidence on physiochemical properties of CMS in comparing with control/reference site. Therefore, a comprehensive experimental data collection on coal mine spoil properties including some control/reference site is required to provide holistic rehabilitation measures.

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