Assessment of vegetation establishment on different tailings depot at an iron ore-mining site of Gol-e-Gohar, Sirjan, Iran, three years after depot

Naseri Hamidreza H.R., 1, Ahmadi Kohbani, M. R. 2, Azizabadi Farahani, E. 3, Yazdanpanah Shahabadi, A. 1
International Desert Research Center, University of Tehran, Iran 1
Gol-e- Gohar Mining and Industrial Company, Sirjan, Iran 2

Abstract: Nowadays, the ecological restoration of mining tailings has become one of the urgent tasks for mine managers and environmental engineers all over the world. The present paper aims to highlight how the reaction of different iron ore tailings to the natural revegetation process. For this purpose, three tailing forms were selected in Gol-e- Gohar mining region, Sirjan city, Kerman province, Iran. These types of mineral tailing are dry tailings depots, wet tailings, and overburden and three years passed after their depot. These three iron ore tailing forms are the main elements of iron exploitation. For vegetation assessment, using 2m2 plots in each different tailing depot, plant species were recorded. All plant data was transferred to R software. Finally, 45 plant species belong to 18 genera were recorded in the adjacent un-mined site as a control area. To evaluate the diversity of vegetation composition, the Shannon - Wiener index was performed and plant diversity was obtained for each tailing. According to the results, the Overburden vegetation with an index of 1.49 has the highest diversity after the control area (1.95) and supports a larger number of plant species (21 species). Wet tailings and un-stabilized dry tailings have the least plant diversity (0.00), while mulch-stabilized dry tailings support a larger number of plant species (Four species and 0.96 Shannon index). The results show that to restore the vegetation of different tailings, local raw materials and overburden should be used due to their nutrients and strong seed bank.

Keywords: IRON ORE, TAILING, RESTORATION, SHANNON- WIENER INDEX, IRAN

1. Introduction

The resources in any form play the most important roles in civilization and human life. The imagination of a world without resources like water, soil, air, and plants is almost impossible, so attention to these ingredients of the earth is too important for any planning for the current time or future. The land in public opinion does not similar to other resources, but the growth of civilization heavily relies upon the lands and the mining industry is one of the most important human activities to operate and maintain comfort. Industrial activities have both positive and negative consequences. Surface mining for iron, coal and other valuable geological materials has been causing severe ecological disturbances worldwide since prehistoric times. The rate of consumption of mineral resources is still increasing due to the acceleration of urbanization, population growth, and the advancement in technology and science, which has been exceptionally fast in the 20th and 21st centuries [1]. The result for mining activities on the surface is mining wastes and alteration of landforms, which is a concern to the society and it is desired that the pristine conditions be restored [2]. The mining disrupts the aesthetics of the landscape along it disrupts soil components such as soil horizons and structure, soil microbe populations, and nutrient cycles which are crucial for sustaining a healthy ecosystem and hence destroy existing vegetation and soil profile [3]. The mineral extraction process must ensure the return of productivity of the affected land and this is necessary for mine managers, which will ensure the health of ecosystems will be good at the final processing of mining. Reclamation is the process by which derelict or highly degraded lands are returned to productivity, and by which some measures of biotic function and productivity is restored. Despite common sight public opinion, reclamation of degraded lands and mineral tillage is a time-consuming process. Since soil is a living system, it has the potential to return to health over time with a regeneration program. Long-term mine spoil reclamation requires the establishment of stable nutrient cycles from plant growth and microbial processes[4, 5]. Soil provides the foundation for this process, so its composition and density directly affect the future stability of the restored plant community. Restoration of vegetation cover on mining tailing dumps can fulfill the objectives of stabilization, pollution control, visual improvement, and removal of threats to human beings. The commonly applied technique in the reclamation of derelict-mined lands, in general, involves the reconstruction of topsoil and planting [6]. In many of the mine sites, however, availability of sufficient soil can be a constraint for such operations, so natural succession is the available method for this purpose.

Tailing, in context to mining, is defined as the waste or noneconomic by-product generated during mining activities, processing of minerals, and other materials that contain small amounts of residual valuable minerals, chemicals, water, and heavy metals [7] so the purpose of this study is to investigate the status of vegetation in mineral tailings in Gol-e- Gohar mines. These mines are one of the largest iron mines in Iran and play an important role in the development of steel industries in Iran. The whole area of Gol-e- Gohar mines has been part of semi-arid rangelands [8] that have been changed due to iron ore extraction. Since vegetation restoration is one of the long-term plans of the managers of these mines, the present study was conducted to evaluate the potentials of iron ore tailings for the establishment of vegetation.

2. Materials and Methods

2.1 Study Area

The study area

The study area is part of the Gol-e- Gohar mining area (29°05’02”N 55°20’58”E) and mining activities are currently being carried out in it. This area is a desert region with a temporal salt lake (Kavire-e- Sirjan in Persian) located in the west part of main pits nearby Sirjan – Shiraz road (Figure 1). The mean annual temperature and mean annual rainfall during 2005-2015 were 18°C and 124 mm. Rainfall regime of the study area, similar to most of the central and desert regions of Iran, is the Mediterranean so almost 70% to 80% of the annual precipitation is concentrated in the months from September to March, while less than 5% occurs in the summer.

Drought index in the study area based on available statistics and the relationship of De Martonne aridity index is equal to 4.60, which according to the climatic classification Gol-e- Gohar range has a dry climate.

The average elevation of study area is roughly 1700 meters above sea level. Much of study area covered by native halophyte, e.g., Halocnemum strobilaceum M.B. and non-halophyte species Artemisia sieberi Besser and and Zygophyllum eurypterum Boiss. & Buhse.

hmaseri@ut.ac.ir
2.2 Methods

Three iron ore tailing forms in this study were selected from different parts that have been at least three years since their depot. The soil and vegetation have been destroyed during the Extraction of iron ore, in these parts. Three main Iron ore tailing forms are the main elements of iron exploitation are. Wet tailings collected in the form of sediments in the tailings dam, Iron ore dry tailings and finally Overburden. Three sections of masses created from different mineral tailings were selected for study.

In the case of dry tailings depots, we face two types of tailing Depots. Mulch-stabilized tailings and non-stabilized tailings. To assess the vegetation, in the first step, the natural vegetation as the control area was evaluated. To identify plant species in this area, work was done by 2 m² plots and collecting different plant species in each plot. In each treatment, 20 plots were established and evaluated separately. Unknown species were transferred to the plant herbarium at the University of Tehran for identification. The same method for collecting plants on iron ore tailings includes dry tailings depots (Mulch-stabilized and, Non-stabilized), wet tailings, and mineral overburden. The names of all plant species were entered in the form of cover percentage in R software. Then, the number of species as Richness and the Shannon - Wiener index for plant diversity were calculated in different mineral tailings and the natural vegetation.

3. Results and Conclusion

In total, 45 plant species belonging to 18 genera identified in the natural cover of the tailings depot margin, in which the Poaceae and Asteraceae genus have the highest presence in the plant species composition with 15%. After that, the Chenopodiaceae(12.5%), Brassicaceae(7.5%), Lamiaceae(7.5%), and Papilionaceae(7.5%) have the highest presence in the plant composition, respectively (Fig. 2).

The richness and diversity in mineral tailings depot vegetation and the control area shown in Table 1. According to the results, after Natural vegetation, overburdens vegetation has the highest richness and diversity, while the vegetation located on other tailings has high difference from the control area. The percentage of vegetation in different treatments also shows that it is directly related to the diversity of plant species. In fact, the high diversity indicates the potential of vegetation in the production of biomass; more biomass also leads to a higher percentage of cover.

Tailings stored in tailings reservoirs or depots not only occupy vast amounts of land, resulting in environmental pollution but also require special treatment in order to avoid its hazards so some practices like mulching or vegetation establishment are very important for this purpose. Since these types of practices are very complicated in every case and in each type of tailing so this not strange that tailings have become a big problem for mineral enterprises.

According to results after three years spite of the mulching operation on dry tailings depot, just a few species could establish on this type of tailing. [9] have stated some of the tailing sites, due to natural succession, can achieve plant settlement with some tolerant species, the establishment of Salsola sp, Londesia eriantha, and Halocnemom strabilaceum which could tolerate severe environmental conditions confirms this consequence.

Salinity is a predominant character of dry and wet iron ore tailing. The exploitation of mines has seriously damaged the ecological environment, resulting in a sharp decline of biodiversity; hence, the total number of plants, which established on tailing, is very limited. In addition to salinity, some important reasons for the limitation of vegetation development on iron ore tailing in Gol-e-Gohar mining site are tiny particles of tailing and shortage of nutrient elements like N and P.

[10] believes the natural restoration of the mine wasteland is rather slow, some are unlikely to be restored naturally, so this can be inferred that the disturbance caused by mining operations has severe effects on the soil, and this disturbance, along with the nutritional problems of the tailings, prevents the establishment of vegetation. [10] has stated in these worst conditions, the natural restoration and revegetation occur often require 50–100 years, especially for the remediation of the soil, which may take 100 to 10,000 years.

As the plant diversity and richness show, the Overburden vegetation is more similar to the natural vegetation of the area and is in the same category as the natural (control) vegetation. In fact, Overburden in Gol-e-Gohar mines is the surface layer of the earth that includes soil and its biological components. Overburden is not essentially waste and its nature is different from dry and wet waste.
Therefore, after turbulence, due to the presence of soil microorganisms and a strong seed bank, it has the ability to recover and regenerate.

Capping, or covering the surface of the tailings with a layer of soil from an adjacent un-mine site is a widely accepted and effective restoration practice [11] so it seems Overburden can used as a vital layer on the surface of other tailings for revegetation. Many studies have shown that the restoration of biological diversity is suppressed in mines without surface backfill [12, 13]; therefore, it is unlikely that ecological restoration will be carried out in the short term without topsoil. Vegetation establishment on derelict wastelands in mining area can be extremely slow by natural processes. Soil condition and soil seed bank are the key limiting factors [14, 15]. This is an important issue that the mine managers should notice and save top soil for future restoration plans. Gol-e-Gohar mining site is located in an arid area so, in addition to the tailing challenge, aridity is another change that can affect the revegetation program, so To control the destructive effects of mineral tailings, a long-term plan such as mulching and seed and shrub operations should be considered.

Acknowledgement

This research have been supported by the Gol-e-Gohar mining and industrial company. We thank our colleagues from the International Desert Research Center of the University of Tehran who provided insight and expertise that greatly assisted the research; we also thank to Mr. Amir Hajizadeh the head of Gol-e-Gohar Research and Technology Management for his valuable support.

4. References