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Physico-Chemical and Phytosociological Analyses of Mine Spoil Dump in Madurai District of Tamil Nadu, India

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Abstract
Rehabilitation of mined area has become one of the most prioritized areas of research in India. In Madurai district of Tamil Nadu extensive mining of granite is operated on about 50 square kilometers area. The present study has been made to analyze the physico-chemical properties of granite mine soil. It is also aimed to document the floral diversity in mine dump. A great variety of microorganisms such as *Azospirillum*, Phosphobacterium and AM fungi have been found in mine spoil. A total of 43 plant species distributed among 40 genera belonging to 30 families were recorded from the study sites. Phytosociological analysis shows that, *Prosopis juliflora* is found to be a predominant tree species grown in spoil dumped area followed by *Morinda tinctoria* and *Azadirachta indica*. There is no nitrogen fixing tree species recorded. The findings of this study can be utilized for mine management programs by creating re-vegetation with suitable tree species in large scale and also for soil management of granite waste dumped area.

Keywords
Madurai district, Mine spoil dump, Physico-chemical properties, Plant resources.

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1. INTRODUCTION:
Environmental impacts due to granite mining are those generally attributed to open cast mines. The major human activities, which cause desertification, are mining disturbances, deforestation, non-planned and non-regulated overgrazing, cultivation (tillage agriculture) and excessive use of off-road vehicles. Reclamation of granite mine waste affected sites has been difficult because coarse tailings have extremely low in water holding capacity, lacks organic matters, deficient in nitrogen and phosphorus and devoid of root symbionts such as mycorrhizal fungi and *Rhizobium* sp. [1].

Different physical, chemical and biological remediation technologies have been developed during previous decades for remediation process [2]. Because of physical and chemical technologies are unsuitable for large areas such as mining sites [3], plant-microbe-based technologies are more suitable and efficient for improving the quality of degraded landscapes [4,5].

There is a need to develop effective planning and environmental management strategy to be adopted for preserving eco-diversity and eco-restoration of mine spoil. Plants those have adaptation mechanisms for growth on polluted sites and can be used for restoration of degraded soils. This flora will help for developing introduction of suitable tree species for soil binder, nitrogen fixation for improving the soil fertility.

Granite mining operations in Madurai district of Tamil Nadu are creating numerous problems leading to the environmental degradation. In Madurai district extensive mining of granite is going on about 50 square kilometers area. After collecting the granite from the mining site, the residual rock is dumped within the mining leased area as heap ranges from 10-15 m. Every year the dumping area is increasing at the rate of 50 ha. In addition to the mine spoil dumps, there is another material called mine reject is also dumped near the mining area. Having these facts as research view, the present study was aimed to assess the physical, chemical and phytosociological properties of mine spoil dump in Madurai district of Tamil Nadu, India.

2. MATERIALS AND METHODS:

2.1. Geographical profiles of study sites

Totally 5 different mine spoil dumped area in Madurai district were selected for this study. They are Karuppayurani (78.1778º E, 9.9329º N), Kalmedu Nagar (78.1890º E, 9.9026º N), Kalimangalam (78.2411º E, 9.8804º N), Kunnathur (77.9110º E, 9.7576º N) and Varichiyur (78.2568º E, 9.9102º N). The longitude and latitude data were given in respective parentheses next to the name of study site. The altitude of the study sites is about 100 – 132 M above mean sea level (MSL). The temperature ranges from 21º C during winter to 41º C during summer. The study sites received an average annual rain fall of about 300 – 750 mm.

2.2. Methodology

2.2.1. Characterization of soil samples

The soil samples collected from spoil dumped areas were analyzed for their physical and chemical properties by using standard procedures [6].

2.2.2. Identification of beneficial microbial population

The dilution plate counting method was employed for the enumeration of microbial population in the soil samples. Appropriate dilutions were done with Pikovskaya's medium for Phosphobacteria [7] and N-free semi solid malate medium for *Azospirillum* [8]. The colonies were counted on third day using colony counter and expressed the population in Colony Forming Units (CFUs) per gram of soil. AM spore density in the rhizosphere soil was enumerated by a modified wet sieving and decanting technique as described by Gerdemann and Nicolson [9] and mycorrhizal root infection was assessed by following the procedure of Phillips and Hayman [10].

2.2.3. Authentication of plant resources

The plants existing in spoil dumped sites were recorded and enumerated. The plants were botanically identified with the help of regional floras [11, 12] and authenticated as per APG IV classification [13].

3. RESULTS AND DISCUSSION:

3.1. Physico-chemical properties of soil of mine spoil dumped area

The data related to various physical and chemical parameters of soil collected from mine spoil dumped area is given in Table 1. As per the research findings, the soil is identified as clay soil with gravel (11.08%), sand and silt (26.24%), and clay (62.68%). The p^H of the soil is estimated as 8.73, electrical conductivity at 25°C as 1007 mmho/cm, water holding capacity as 39.50%, alkalinity as 0.0113% and organic content as 0.32%. About 0.019% of chlorides and 0.007% of sulfates have been assessed in the soil sample. Among the macronutrient content of the soil, nitrogen, phosphorus, potassium, calcium and magnesium are about 0.22%, 0.03%, 0.12%, 0.092% and 0.031% respectively. In case of micronutrient, sodium, copper, nickel, chromium, lead and zinc are estimated as 0.068%, 0.0010%, 0.0008%, 0.0002%, 0.0012% and 0.008% respectively (Table 1).

It was reported that loamy textures is generally ideal in mine spoil dump and silt loam textures are common where spoils are dominated by siltstones [14]. Ghose [14] reported that the maximum sand content was 66% and clay only 8.6% in mined soil. However, the findings of present estimate are not corroborating with earlier report and it was estimated that the soil is clay. Singh *et al*. [15] and Singh and Singh [16] also reported maximum content of sand (80%) and least content of clay (11%) at the Singrauli coal field.

3.2. Microbial populations of soil of mine spoil dumped area

The microbial population in the soil sample collected from mine spoil dump had an indigenous AM fungal population of 23 propagules per 100 g soil as assessed by most probable number [17] and indigenous AM flora consisted of *Acaulospora scrobiculata* Trappe, G*lomus aggregatum* N.C. Schenck & G.S. Sm., *G. geosporum* (Nicol. & Gerd.) Walker and *G. sinuosum* (Gerd. & B.K. Bakshi) R.T. Almeida & N.C. Schenck. The *Actinomycetes*, *Azospirillum* and Phosphobacterium populations were found as 15×10^4, 3×10^4 and 4×10^4 CFUs g^{-1} respectively (Table 2).

It was stated that the soil microbes include several bacterial species active in decomposition of plant material as well as fungal species whose symbiotic relationship with many plants facilitates uptake of nitrogen and phosphorus in exchange of carbon. They produce polysaccharides that improve soil aggregation and positively affect plant growth [18]. Soil microorganisms play an important role in transformation of organic matter [19]. Abundance and activity of microorganisms reflects the degree of soil development [20]. Their activity is essential for nutrient cycling, formation of available forms of nutrients and development of soil [21]. Hence, determination of plant and microbial diversity provide valuable information for restoration of mining activities in degraded environments. In the present study analysis of soil sample collected in mine area shows that there is no detectable number of *Azotobacter* found in the sample and it was corroborated with plant and microbial diversity in coal mine-affected soil at Kakanj of Bosnia and Herzegovina [22].

3.3. Plant resources of mine spoil dumped area

The plants habiting in mine spoil dumped area were listed in Table 3. A total of 43 species belonging to 40 genera distributed among 27 families were enumerated from the study sites. The family Malvaceae was recorded as dominant family with 5 species. Fabaceae, Rubiaceae, Asteraceae and Apocynaceae were recorded with each of 3 species and Cleomaceae, Lamiaceae, Amaranthaceae and Euphorbiaceae with 2 species each. Rest of the 16 families were noted as monospecific (Table 3; Fig. 1). Based on life forms of the plants, herbaceous plants occupied the spoil dumped area majorly (21 nos., 48.84%), followed by climbers and trees (8, 18.60 each) and shrubs (6, 13.96) (Table 3; Fig. 2). It was also noted that *Prosopis juliflora* was found to be a predominant tree species grown in mine spoil dump followed by *Morinda tinctoria* and *Azadirachta indica*.

The areas of dump in Madurai district are devoid of dense vegetation due to high p^H, low water holding capacity, lack of nutrients and microorganisms. Soil particles those smaller than 2 mm are responsible for majority of water and nutrient holding capacity in the mine soils. Particles larger than 2 mm are referred to as "coarse fragments". Soils constituting high coarse fragments have larger pores that cannot hold enough water available for plant growth against leaching to sustain vigorous growth over the summer months.

In the present survey, population of tree species is poor particularly there is no any nitrogen fixing trees. Nitrogen fixing species have a dramatic effect on soil fertility through production of readily decomposable nutrient rich litter and turnover of fine roots and nodules. In this concern, *Casuarina* is most preferred species for ecorestoration and environmental protection. Species trial conducted in Quartz sand dump at Madukkarai in Coimbatore district of Tamil Nadu indicated that the *Casuarina equisetifolia* using rooted cuttings perform better growth (3.34 m), and total biomass (5.844 kg/tree). From that it was recommended that *Casuarina* can be used for afforestation and reclamation of Quartz sand dump [23]. The nitrogen fixing trees like *Casuarina equisetifolia*, *Casuarina junghuhniana*, *Leucaena leucocephala*, *Sesbania sesban*, *Acacia nilotica*, *Pithecellobium dulce*, *Erythrina variegata*, *Pongamia pinnata, Acacia auriculiformis*, *Acacia leucophloea*, *Dalbergia latifolia*, *Dalbergia sissoo*, *Albizia lebbeck* and *Gliricidia sepium* are not only fix the atmospheric nitrogen but also produce the high amount of litter for improve the soil fertility and moisture conservation. They also grow well low rain fall area in semiarid zone of southern part of Tamil Nadu. Mineralization of N-rich litter from these species allow substantial transfer to companion species and subsequent cycling, thus enabling the development of a self-sustaining ecosystem [24].

Table 1: Physico-chemical parameters of soil sample

Physico-chemical parameters	Findings
Soil type	Clay soil
p^H	8.73
Electrical conductivity (at 25º C)	1007 mmho/cm
Water holding capacity	39.50%
Alkalinity	0.0113%
Organic content	0.32%
Chloride	0.019%
Sulfate	0.007%
Nitrogen	0.22%
Phosphorus	0.03%
Potassium	0.12%
Calcium	0.092%
Magnesium	0.031%

Sodium	0.068%
Copper	0.0010%
Nickel	0.0008%
Chromium	0.0002%
Lead	0.0012%
Zinc	0.008%

Table 2: Microbial population assessment in soil sample

Microbial assessment	Findings
Actinomycetes (cfu/g of dry soil)	15×10^4
Azospirillum (cfu/g of dry soil)	3×10^4
Phosphobacterium (cfu/g of dry soil)	4×10^4
AM spore/100 g of dry soil	23
AM infection (%)	82

Table 3: Plants recorded in the study sites, arranged as per APG IV classification [13]

S. No.	Family	Botanical name	Habit	Local name
1	Menispermaceae	*Tinospora cordifolia* (Thunb.) Miers	Climber	Seendhilkodi
2	Cleomaceae	*Cleome gynandra* L.	Herb	Thaaivaelai
3	Cleomaceae	*Cleome viscosa* L.	Herb	Naaikkadugu
4	Violaceae	*Hybanthus enneaspermus* (L.) F.Muell.	Herb	Oorithazhthaamarai
5	Malvaceae	*Abutilon indicum* L.	Shrub	Thuththi
6	Malvaceae	*Pavonia odorata* Willd.	Herb	Paeraamutti
7	Malvaceae	*Pavonia zeylanica* (L.) Cav.	Herb	Sithaamutti
8	Malvaceae	*Sida acuta* Burm.f.	Herb	Arivaalmanaippoondu
9	Malvaceae	*Sida cordifolia* L.	Herb	Nilathuththi
10	Zygophyllaceae	*Tribulus terrestris* L.	Herb	Nerunji
11	Meliaceae	*Azadirachta indica* A.Juss.	Tree	Vaembu
12	Rhamnaceae	*Ziziphus* jujuba Mill.	Tree	Yilandhai
13	Vitaceae	*Cissus quadrangularis* L.	Climber	Pirandai
14	Sapindaceae	*Cardiospermum halicacabum* L.	Climber	Mudakkathaan
15	Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Tree	Udhiyamaram
16	Fabaceae	*Prosopis juliflora* (Sw.) DC.	Tree	Karuvaelam
17	Fabaceae	*Senna auriculata* (L.) Roxb.	Shrub	Aavaarampoo
18	Fabaceae	*Tephrosia purpurea* (L.) Pers.	Herb	Kozhungi
19	Passifloraceae	*Passiflora foetida* L.	Climber	Anilpazham
20	Cucurbitaceae	*Citrullus colocynthis* (L.) Schrader	Climber	Kumatti
21	Cactaceae	*Opuntia stricta* (Haw.) Haw.	Shrub	Sappaathikkalli
22	Molluginaceae	*Mollugo nudicaulis* Lam.	Herb	Parpaadagam
23	Rubiaceae	*Canthium coromandelicum* L.	Shrub	Nallakaarai
24	Rubiaceae	*Morinda tinctoria* Roxb.	Tree	Manjanathi
25	Rubiaceae	*Oldenlandia umbellata* L.	Herb	Empural
26	Asteraceae	*Parthenium hysterophorus* L.	Herb	Mookkuthippoo
27	Asteraceae	*Tagetes erecta* L.	Herb	Chevvanthipoo
28	Asteraceae	*Tridax procumbens* L.	Herb	Vettukkaayapoondu
29	Apocynaceae	*Calotropis gigantea* (L.) R.Br.	Shrub	Yerukku
30	Apocynaceae	*Oxystelma esculentum* (L.f.) Sm.	Climber	Oosippaalai
31	Apocynaceae	*Pergularia daemia* (Forssk.) Chiov.	Climber	Vaelipparuthi
32	Pedaliaceae	*Pedalium murex* L.	Herb	Yaanainerunji
33	Acanthaceae	*Andrographis echioides* (L.) Nees	Herb	Koburanthaangi
34	Lamiaceae	*Vitex negundo* L.	Tree	Nochi
35	Lamiaceae	*Ocimum americanum* L.	Herb	Naaithulasi
36	Nyctaginaceae	*Boerhavia erecta* L.	Herb	Saaranathi
37	Amaranthaceae	*Aerva lanata* (L.) Juss. ex Scult.	Herb	Kooraipoo
38	Amaranthaceae	*Alternanthera sessilis* (L.) R.Br. ex DC.	Herb	Ponnaanganni

39	Aristolochiaceae	*Aristolochia indica* L.	Climber	Aaduthinnaappalai
40	Euphorbiaceae	*Jatropha gossypiifolia* L.	Shrub	Aathaalai
41	Euphorbiaceae	*Tragia involucrata* L.	Herb	Sirusenthatti
42	Ulmaceae	*Holoptelea integrifolia* (Roxb.) Planch.	Tree	Aavimaram
43	Moraceae	*Ficus benghalensis* L.	Tree	Aalamaram

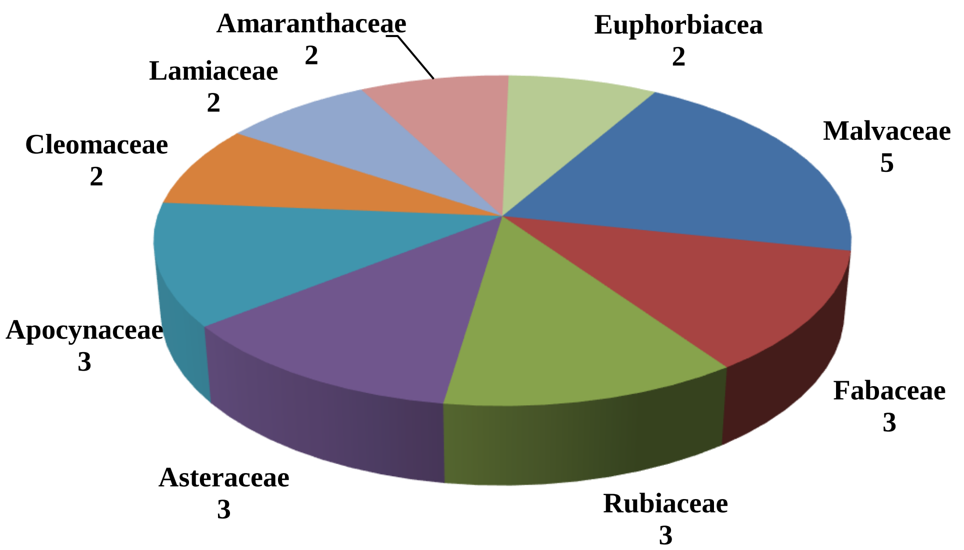

Figure 1: Family wise contribution of plants recorded from the study sites

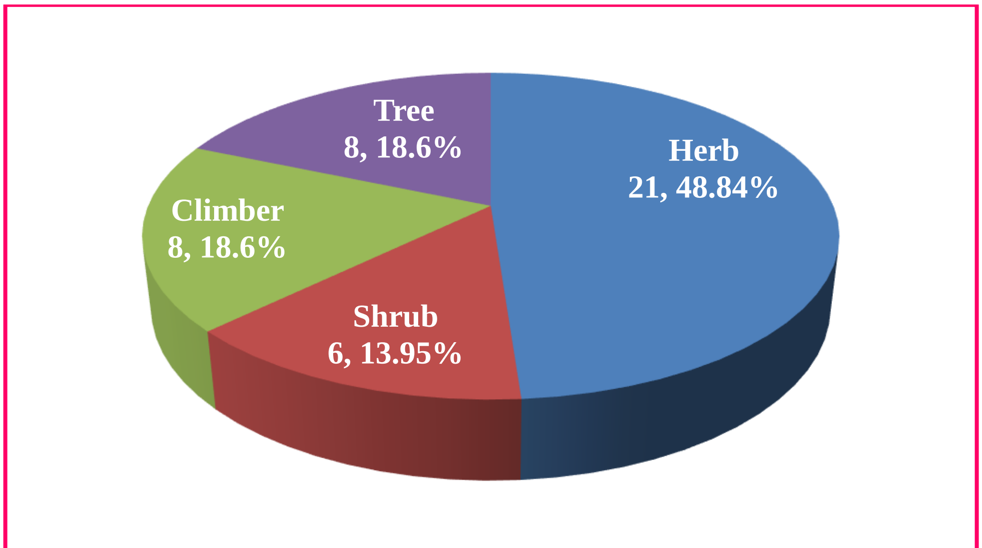

Figure 2: Habit wise contribution of plants recorded from the study sites

4. CONCLUSION:

Reclamation of mined-over area is a difficult task. The task essentially calls for sound research base, research problems related to soil and site, selection of suitable tree species for reclamation and soil binders with soil improvement, suitable method of soil moisture conservation using locally available organic waste, selection of beneficial microorganism particularly helper bacteria and fungi (AM fungi) for the sustainable nutrient management and tree afforestation etc. needs to be standardized to the reclamation of mine spoil dump and increase biological diversity particularly nitrogen fixing tree species there by mitigate the global warming through floral cover.

5. REFERENCES:

[1] Noyd, R.K., Pfleger, F.L., Norland, M.R. and Hall, D.L. (1997). Native plant productivity and litter decomposition in reclamation of taconite iron ore

tailing. Journal of Environmental Quality, 26: 682-687.

[2] Mulligan, C.N., Young, R.N. and Gibbs, B.F. (2001). Remediation technologies for metal-contaminated soils and groundwater: an evaluation. Engineering Geology, 60: 193-207.

[3] Khan, A.G. (2005). Role of soil microbes in the rhizosphere of plants growing on trace metal contaminated soils in phytoremediation. Journal of Trace Elements in Medicine and Biology, 18: 355-364.

[4] Rosenvald, K., Kuznetsova, T., Ostonen, I., Truu, M., Truu, J., Uri, V. and Lohmus, K. (2011). Rhizosphere effect and fineroot morphological adaptations in a chronosequence of silver birch stands on reclaimed oil shale post-mining areas. Ecological Engineering, 37: 1027-1034.

[5] Dilly, O., Bach, H.J., Buscor, F., Eschenbach, C., Kutsch, W.L., Middlehoff, U., Pritsch, K. and Munch, J.C. (2000). Characteristics and energetic strategies of the rhizosphere in ecosystems of the Bornhoved Lake district. Applied Soil Ecology, 15: 201-210.

[6] Carter, M.R. and Gregorich, E.G. (2006). Soil sampling and methods of analysis (2nd ed.), Taylor & Francis Group, CRC Press, USA.

[7] Sundara Rao, W.V.B. and Sinha, M.K. (1963). Phosphate dissolving organisms in the soil and rhizosphere. Indian Journal of Agricultural Science, 33: 272-278.

[8] Dobereiner, J., Marriel, J.E. and Nery, J. (1976). Ecological distribution of *Spirillum lipoferum* Beijerinick. Canadian Journal of Microbiology, 22: 1461-1473.

[9] Gerdemann, J.M. and Nicolson, T.H. (1963). Spores of mycorrhizal endosome species extracted from soil by wet sieving and decanting. Transaction of British Mycological Society, 46: 235-244.

[10] Phillips, J.M. and Hayman, D.S. (1970). Improved procedures for clearing roots and staining parasite and vesicular arbuscular mycorrhizal fungi for rapid assessment of infection. Transaction of British Mycological Society, 55: 158-161.

[11] Gamble, J.S. and Fischer, C.E.C. (1915-1936). Flora of the Presidency of Madras, Vols. I – III. Botanical Survey of India, Calcutta (reprinted in 1957).

[12] Matthew, K.M. (1991). An Excursion Flora of Central Tamil Nadu. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.

[13] APG IV. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants. Botanical Journal of the Linnean Society, 181(1): 1-20.

[14] Ghose, M.K. (2005). Soil conservation for rehabititation and revegetation of mine degraded land. Teri information Digest on Energy and Environment, 4(2): 137-150.

[15] Singh, A.N., Raghubanshi, A.S. and Singh, J.S. (2004). Impact of native tree plantations on mine spoil in a dry tropical environment. Forest Ecology and Management, 187: 49-60.

[16] Singh, A.N. and Singh, J.S. (2006). Experiments of ecological restoration of coalmine spoil using tree plantation in a dry tropical environment, India: A synthesis. New Forest, 31: 25-39.

[17] Porter, V.M. (1979). The most probable number method for enumerating infective propagules of Vesicular Arbuscular Mycorrhizal fungi in soil. Australian Journal of Soil Research, 17(3): 515-519.

[18] Williamson, J.C. and Johnson, D.B. (1991). Microbiology of soils at opencast sites: II. Population transformations occurring following land restoration and the influence of rye grass/fertilizer amendments. Journal of Soil Science, 42: 9-16.

[19] Zhao, Z.Q., Shahrour, I., Bai, Z.K., Fan, W.X., Feng, L.R. and Li, H.F. (2013). Soils development in opencast coal mine spoils reclaimed for 1-13 years in the West-Northern Loess Plateau of China. European Journal of Soil Biology, 55: 40-46.

[20] Helingerova, M., Frouz, J. and Šantruĉkova, H. (2010). Microbial activity in reclaimed and unreclaimed post-mining sites near Sokolov (Czech Republic). Ecological Engineering, 36: 768-776.

[21] Heras, M.M., Nicolau, J.M. and Espigares, T. (2008). Vegetation succession in reclaimed coal-mining slopes in a Mediterranean-dry environment. Ecological Engineering, 34: 168-178.

[22] Hamidović, S., Ĉolo, J., Kiković, D., Krivošej, Z., Lalević, B. and Milinković, M. 2013. Plant and microbial diversity in coal mine-affected soil in “Kakanj” (Bosnia and Herzegovina). Zaštita Materijala, 54: 403-408.

[23] Ponnambalam, A., Sugavanam, V., Devaraj, P. and Jayaraj, R.S.C. (1998). Growth response of *Acacia auriculiformis* and *Casuarina equisetifolia* in quartz sand dumps from cement factories. Journal of Arid Land Studies, 7S: 315-318.

[24] Zhang, Z.Q., Shu, W.S., Lan, C.Y. and Wong, M.H. (2001). Soil seed bank as an input of seed sources in vegetation of lead/zinc mine tailings. Restoration Ecology, 9(4): 1-8.