CHAPTER V
5.1 Chromite Overburden in Relation to Crop Production:

The Kaliapani chromite mines in Sukinda Block of Cuttack district in Orissa have very rich deposits of chromite ore. These mine areas produce about 5.61 lakh tonnes of chromite every year out of total Indian Production of six lakh tonnes and this comprises around 93.5%. About 1,365 hectares is the leased area by Orissa Mining Corporation and a vast leased area by Tata Iron and Steel Company (TISCO) for excavation of chromite ore which leads to huge dump of overburdens on the soil surface. As it is estimated, to mine 1 ton of chromite ore about 8-10 tonnes of overburdens are being generated. These overburdens are dumped in close proximity of the mines often reaching a height of about 30 m and are rich in Al, Fe, Mn, Ni, Co and Cr and deficient in organic carbon, N, P, K, Ca, and Mg. These are acidic in reaction and pose serious toxic problems for natural vegetation. These heavy metallic ions upon washed from chromite overburdens by rain water pollute ground water, river and pond water thereby making it unsafe for human and animal consumption. These polluted water when used for irrigation purposes also affect the local crops (at
the toxic levels of heavy metals) and on their consumption pose health problems to animals and human beings. The crops like cereals, millets, maize, pulses, and oil seeds and vegetables suffer seriously at different stages of their growth. The soil and water is polluted by these heavy metals in these areas.

With rapid increase of population, these overburden dumps are to be reclaimed and made productive to the economic conditions of the State. "Destruction can be replaced by restoration". With this view in mind, the Regional Research Laboratory, Bhubaneswar, had taken up plantation work at Kaliapani on the chromite mine overburdens since 1985. As it was reported by Dutt et al., (1988) that the survival percentage of Eucalyptus, Acacia, Cassia, Leucinia, Casuarina were to the extent of 80-85% as on 2nd November, 1988 and that of Lemongrass and Palmarosa was nil. This clearly indicates that there are some problems in overburdens which hinder the growth and development of these economic plants by interfering in its absorption and translocation of essential nutrients from soil. As these economic plants like Lemongrass and Palmarosa could not thrive in overburden soils possibly due to presence of 25.7% Fe$_2$O$_3$, 6.6% Cr$_2$O$_3$ and 16.8% of Al$_2$O$_3$, it was high time for some reclamation work and accordingly this project
was planned and carried out in this overburden (soils) at Regional Research Laboratory, Bhubaneswar, Orissa.

5.2 Growth of Aromatic and Medicinal Plants in Chromite Overburdens

In comparison to other food crops, the medicinal grasses usually overcome many problems during their growth and development. These problems may be due to abnormal climatic conditions such as temperature fluctuations, high and low rain fall and sun—shine hours or due to soil environment such as soil pH, micro—organisms, deficiency of essential cations, toxicity of micro and heavy metals and soil moisture fluctuations. Besides their tolerance to many problems as said earlier the essential oil and other perfumery products of these medicinal grasses earns foreign exchange for our country besides meeting the pharmaceutical and perfumery materials required by our country. With the growing demand for the essential oils therein, production/yield should also increase. The production of aromatic and medicinal plants can be increased in two ways such as (i) by increasing the area and (ii) by increasing the yield of unit area with scientific methods of agriculture, viz., with application of organic manures, lime and fertilisers, pesticides and fungicides. These medicinal plants when are grown in chromite overburdens, the area is increasing side by side the production/yield is increasing with application of fertilisers,
organic manures and lime. If this mission succeeds then the vast overburdens around the chromite mines in our State and Country will be properly utilised.

For growing crops successfully on this problematic soil, it is desirable to assess the magnitude of interfering elements/factors in crop growth and development (metabolism). As the total toxic elements comprise about 50% (Fe$_2$O$_3$=25.7, Al$_2$O$_3$=16.8%, Cr$_2$O$_3$=6.6%, Ni=0.5 to 1.0% and Co=0.3 to 0.5%), upon dissolution these elements interfere with the availability and translocation of essential elements like N, P, K, Ca, and Mg in many ways by aromatic and medicinal plants. It is confirmed that Al and Fe interfere in converting soluble orthophosphates into insoluble AlPO$_4$ and FePO$_4$ (Kittrick et al., 1955) including their toxic effects on plant roots (Ragland and Coleman, 1959). Chromium on the other hand causes root damage and interferes in plant metabolism with toxic symptoms (Goto et al., 1977, Bonter et al., 1953 and Turner et al., 1971).

5.3 Fertilisers, Organic Manures and Lime Yield and Yield Attributing Characters of Aromatic Plants in Chromite Overburdens:

The extrapolation of vast natural resources in mine areas is always associated with destruction of natural ecological systems and the rehabilitation of the natural ecology by vegetation and afforestation.
is very important. As stated earlier, the importance of growing medicinal and aromatic plants in these areas with advanced technology over other crops needs no clarification as these crops have triple benefits, i.e., (i) earning foreign exchange, (ii) supplying basic material to domestic pharmaceutical industries, (iii) restoring ecology/checking soil erosion.

Attempts were made to select suitable species for growing on overburden on the basis of their yield and yield attributing characters such as tiller numbers, plant height, chlorophyll content, internodal length, leaf area, herb yield, oil content, etc. To augment the yield and yield attributing characters of these plants, the effects of applied nitrogenous fertilisers in form of urea, P and K, FYM, and lime were analysed and presented in the preceding chapter (Result Chapter).

Plant Height, Tiller Number, Chlorophyll Content, Herb Yield and Oil Content of Aromatic Plants in Overburdens:

The response of these aromatic and medicinal plants to fertilisers, fertilisers along with farm yard manure, fertilisers with lime, fertiliser along with lime and organic matter sources such as farm yard manure, and leucine leaves has been well recognised in the results obtained from the pot culture experiments conducted in chromite overburdens from 1986-87 to 1988-89 at Regional Research Laboratory, Bhubaneswar.
The application of ninety kg of N per hectare alone and in combination with Farm yard manure has significantly increased the plant height, tiller number, chlorophyll content and herb yield of Palmarosa over no nitrogen (control). Simultaneously, a dose of 100 kg N, 50 kg P₂O₅ and 50 kg K₂O per hectare has brought about significant effect on plant height, tiller number, chlorophyll and oil content of Palmarosa, Jamrosa, C. pendulus and C. flexuosus during 1987-88 and 1988-89. This result has a close agreement with results of Gupta et al., (1978), Prakash Rao et al., (1985) and Singh et al., (1983).

The application of 200 kg N, 100 kg P₂O₅ and 100 kg K₂O per hectare although has increased the tiller numbers, plant height, chlorophyll content, oil content and herb yield of Palmarosa, Jamrosa, C. pendulus and C. flexuosus significantly, this dose of fertiliser cannot be recommended for these plants as it will surely produce negative returns due to high cost of fertilisers. The work of Hazarika et al., (1978), Singh et al., (1983) also agrees with this.

The application of lime (CaCO₃) at the rate of 1 LR (6t/ha) or 1.5 LR (9t/ha) has increased the plant height, tiller number, chlorophyll content, oil content and herb yield of Palmarosa, Jamrosa, C. pendulus and C. flexuosus in many instances during 1987-88 and 1988-89. The interactions (effects) of
Lime and fertilizer doses are also significant in many cases. This is because of the fact that lime has depressed the action of heavy metals in overburden and has created better soil environment for the growth of these plants. The application of lime (CaCO₃) at the rate of 6t, 9t and 12t per hectare alone and in combination with 10t FYM per hectare or 1t leucina leaves per hectare had increased the plant height, tiller numbers, chlorophyll and oil content, herb yield and Jamrosa species significantly in three consecutive harvests over control. This is because of the fact that lime has nullified the action of heavy metals like Al, Fe, Cr, Ni, etc., and organic matter like FYM and leucina leaves has created a better soil condition for activity of soil microorganisms. Thereby the essential nutrients have become more available for medicinal plants in these overburdens. Anjos et al., (1987), Pinogenova, (1977) and Mascarenhas et al., (1976) have also confirmed this result.

The correlation studies was also carried out between plant height vs. oil yield, tiller number vs. oil yield, chlorophyll content vs. oil yield, herb yield vs. oil yield, plant nutrients (Fe and Cr) vs. soil pH, DTPA extractable Fe and Cr vs. soil pH of Palmarosa, Jamrosa, C. pendulus and C. flexuosus
during 1987-88, 1988-89 and presented in Table 5.1, 5.2 and 5.3 respectively in the previous chapter.

The correlation studies indicate the correlation coefficients (r) of plant height, tiller number, chlorophyll contents, oil content and herb yields with oil yields of Palmarosa, Jamrosa, C. pendulus and C. flexuosus during 1987-88 and 1988-89 in three consecutive harvests. The correlation studies revealed that tiller numbers and herb yields had positive significant correlations with oil yields of Palmarosa, Jamrosa, C. pendulus and C. flexuosus during 1987-88 (Table 5.1) and herb yields of Palmarosa, Jamrosa, C. pendulus had positive significant correlations with oil yields in three consecutive harvests during 1988-89 (Table 5.1). On the other hand, plant height (cm) had positive significant correlation with oil yields of Palmarosa (except harvest two), Jamrosa, C. pendulus (except harvest three) and C. flexuosus (except harvest one) during 1987-88 (Table 5.1) and plant height had positive significant correlation with oil yields of Palmarosa, Jamrosa and C. pendulus (except harvest one and two) during 1988-89. Chlorophyll and oil content had wide fluctuations in their correlations with oil yields of each species during 1987-88 and 1988-89 (Table 5.1).
Similarly, the soil pH had no significant correlation with oil yields of Palmarosa, Jamrosa, C. pendulus and C. flexuosus during 1987-88 (Table 5.1). This clearly indicates that increasing soil pH by liming never increases the oil yields of these aromatic grasses significantly in chromite overburdens.

5.4 Soil Amendments on Uptake of Plant Nutrients by Aromatic Species:

The availability and uptake of plant nutrients (essential and non-essential) from soil/chromite overburdens is a net effect of applied fertilizer, lime and organic matter on it. In this investigation a recommended dose of fertilizer @ 100 50 50 kg::N, P\(_2\)O\(_5\), and K\(_2\)O per hectare respectively or twice of it was applied keeping in view the sizeable loss of applied N, P and K by heavy metals. The most bothering factor was the availability of P in this overburden and its uptake by aromatic plants such as Palmarosa, Jamrosa, C. pendulus and C. flexuosus. Almost all the species had shown the phosphorus deficiency symptoms at peak of their vegetative growth when fertilizer, lime and organic matters are not being added or lime added at a higher dose (1.5 LR or 2.0 LR). Pradhan et al., (1982) had also confirmed this result. This clearly tells about the conversion of soluble phosphate ions as insoluble Al and Fe phosphates (No lime control) and that of sparingly soluble/insoluble Ca-phosphates
at higher lime doses leading to a soil pH of 7.8 to 8.5. This result well agrees with that of Buehrer (1932). The application of fertilisers, lime and organic matter sources had increased the uptake of N, P, K, Ca, Mg by all the species taken up in the experiments over control (No lime, No fertiliser, No organic matter). The Palmarosa species had taken up N, P, K, Ca and Mg at the rate of 0.654, 0.065, 0.636, 0.730, 0.454 g/pot on an average respectively over the treatments and years at the time of harvests (during 1987-88 and 1988-89). The species Jamrosa had taken up N, P, K, Ca, Mg at the rate of 0.792, 0.057, 0.847, 0.630, 0.461 g/pot on an average respectively over the treatments and years at the time of harvest (during 1987-88, and 1988-89). The species C. pendulus had also taken up N, P, K, Ca, Mg at the rate of 0.874, 0.056, 0.994, 0.654, 0.430 g/pot on an average respectively over the treatments and years at the time of harvests and that of species C. flexuosus was 0.590, 0.044, 0.758, 0.511, 0.350 g/pot of N, P, K, Ca and Mg, respectively over the treatments and years (during 1987-88 and 1988-89) (Tables 4.3 (a), 4.3(b), 4.3(c), 4.4(a), 4.4(b)). Prakash Rao et al. (1985) has also found out this type of result.

Similarly, the uptake of N, P, K, Ca, Mg by Jamrosa species as influenced by lime and organic
matter sources has increased over no lime - no organic matter control (Table 4.5).

The uptake of Cr and Fe has decreased with the addition of fertilisers, lime and organic matter sources by the aromatic grasses taken up in the experiment over control. The additions of lime has decreased drastically the uptake of Fe and Cr in overburden soil by the aromatic species irrespective of fertiliser and organic matter sources are being applied. The application of fertiliser has depressed the uptake to certain extent (less than lime action) due to action of Ca, Mg salts present in superphosphate applied for growth of the species, whereas the effect of organic matter sources alone has not depressed the uptake to an appreciable account. This result well agrees with the result of Mc Lachlan, (1980).

It is again marked that uptake of Cr has a strong relationship with the uptake of Fe. In more than 90% cases the uptake of more Fe is always associated with the uptake of more Cr. This has not depended on the type of species, or on quantity of fertilisers/lime or type of organic matter sources applied in the overburden. This result also agrees with the work of Cary et al., (1977).
5.5 The Amendments on Soil Fertility Change in Overburdens:

The most important approach of the present investigation was to create a favourable soil environment for maximum availability of essential plant nutrients and to provide a seat of maximum biochemical activities of micro-organisms by way of their growth and development in chromite overburden (soils). As the organic carbon content of this overburden is below 0.5% (0.2%-0.3%) and the pH is in between 5.0 to 5.5, i.e., moderately acidic, it indicates the lacking of many essential bacterial flora in it. Side by side the population of other micro-organisms is certainly less due to toxic elements like Al, Fe, Cr, Ni and Co in this overburden. To neutralise the action of toxic elements and enhance the bacterial activity and activity of other micro-organisms, the addition of lime and organic matter sources was given top priority in this investigation. Due importance was also given for the application of fertilisers such as N as urea, P₂O₅ as superphosphate and K₂O as muriate of potash for immediate growth promotion thereby to increase the yield of herbs in chromite overburden.

The pH, say soil reaction, one of the most important chemical characteristics has been influenced by lime, fertiliser and organic matter applications.
The pH of the control soil has also been increased from 5.3 to 6.0 after three consecutive harvests due to continuous application of water only and maintaining the overburden at field capacity throughout the investigation. This leads to conversion of Cr VI to Cr III, which causes an increase of the pH at control. Cary et al., (1977) also had found out this type of result. The application of lime also had maintained the soil pH at 7 or > 7 after three consecutive harvests. The application of fertilisers and organic matter sources also has increased the pH of overburden. This work also agrees with the work of Suresh et al. 1988.

Similarly, the application of 100 kg N or 200 kg N per hectare of FYM 10t/ha has not increased the available 'N' content of overburden appreciably and it has decreased drastically when fertiliser is applied along with lime. The available $P_2O_5$ content has also increased to some extent with addition of fertilisers and lime whereas the available $K_2O$ content has increased with fertiliser application and has decreased with lime. Choudhury et al., (1981), Suresh et al., (1988) have also found out this type of result in acid soils of India.

At the same time, the application of lime and organic matter sources has increased the available N and $P_2O_5$ content in the overburdens whereas the
available K₂O content was increased with organic matter sources and decreased with lime levels. This result also well agrees with the work of Sharma et al., (1988) and Suresh Lal et al., (1988).

DTPA extractable Fe and Cr was increased with addition of only fertilisers in overburden whereas the addition of lime has decreased it. This is due to precipitation of Fe, Al and Cr by the addition of lime as CaCO₃. Cary et al., (1977) has also found out this type of results.

Similarly, the application of organic matter and lime has influenced the DTPA extractable Fe and Cr of the overburden when only Jamrosa species is being grown. Application of lime has decreased the Fe and Cr content of the overburden while the application of organic matter sources has increased Fe and Cr content. The combined effect of lime and fertilisers and lime and organic matter sources has increased the Fe and Cr content of overburden.

5.6 Implication of Nutritional Management for Aromatic Plants in Chromite Overburden:

As stated earlier the chromite overburden poses many problems for cultivable crops including aromatic grasses. To maximise yield and oil content of aromatic and medicinal plants in chromite overburden it is desirable to create a better and suitable
environment for maximum availability of plant nutrient and accelerated activity of micro-organisms. To achieve this, it is high time to inactivate the toxic elements/heavy metals present in chromite overburden and accordingly various approaches are being made in this investigation. As the aromatic and medicinal plants do contain oils and essences of medicinal value, the increase of the oil content along with yield was given with top priority. Phosphorus, calcium and sulphur are thought to be the important elements/factors for protein and oil synthesis in oil bearing plants and calcium alone increases the availability of phosphorus and sulphur from inherent sources in soil/overburden. Therefore, the application of fertilisers, superphosphate has increased the phosphorus and sulphur content in soil as it contains 16% \( P_2O_5 \) and 12% sulphur. Simultaneously the application of lime as \( CaCO_3 \) has increased the calcium content in overburden which also induces the increased availability of phosphorus from Al and Fe phosphates and sulphur from organic matter sources (humus). Again the addition of organic matter sources like FYM and leucaena leaves has acted as the seat for microbial activity.

Therefore, the availability of essential nutrients like N, P, K, Ca, Mg has increased in the overburden due to addition of lime, organic matter sources with a recommended dose of fertilisers such
as 100 kg N, 50 kg $P_2O_5$ and 50 kg $K_2O$ per hectare and in return the toxic elements like Al, Fe, Cr has become insoluble and unavailable to aromatic species in overburden. The net result is the increase of the yield of herbs and oil content in chromite overburden due to application of lime, fertilisers and organic manures.