UNU-PROGRAMME
International Network on Water, Environment and Health

Project Title:

Reclamation of Saline-Alkali Soils using Effective Microorganisms Technology

Name of the organization(s):	**Contact person / designation**
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Authorities responsible
Dr. Syed Ali

Total cost of the project	**Annual expenditure**
Rs. 4.0 million	Rs. 1.34 million

Time required for completion of the project

3 years from the date of disbursement of funds

Executing / implementation organization

- EM Research Organization, 2-9-2 Ganeko, Ginowan City, Okinawa, Japan (HQ)
- EM Research Organization, 211-G-III, Johar Town, Lahore, Pakistan. (Regional Branch for Middle East & Central Asia).

Objectives of the project:

- To investigate the possibility of use of EM Technology for reclamation, its effect on crop yield and soil characteristics
- To investigate the role of EM Technology for improvement of poor quality groundwater for reclamation, its effects on crop yield and soil characteristics
- To demonstrate the effectiveness of EM Technology in comparison to conventional methods of reclamation

Importance of the Project:

Under arid and semiarid climate, characterized by less rainfall and high evapotranspiration rate, generally associated with shortage of canal irrigation water, the saline and alkali soils, that contain an excess of both soluble salts and exchangeable sodium, reduce the value and productivity of considerable areas of good agricultural lands. The reclamation means the adaptation of special remedial measures and management practices according to the occurrence, location, and kind & type and chemical & physical properties of saline and alkali soil profile so as to remove salts and exchangeable sodium from the root zone to the maximum to have good crop production.

Up-till-now the methods adopted for reclamation are removal of salts from saline soils with irrigation water and use of gypsum on almost 98% of lands and sulfuric acid on nearly 2% alkali soils to get rid of sodium from the clay complex. Thus, a period of 2–4 years is required to activate/reestablish the biological life in such lands to make these fertile.

The reclamation of saline and alkali soils using Effective Microorganisms (EM) Technology, a Japanese Technology, invented by Prof. Dr. Teruo Higa, University of Ryukyus, Okinawa, Japan, containing useful and beneficial Microorganisms of 3 main genera (phototrophic bacteria, lactic acid bacteria and yeast) being manufactured/produced in more than 50 countries of the world as EM–1 in known standard concentrations, has been successfully employed to improve salt affected lands in Pakistan obtaining reasonable good yield of rice even in the 1st year of reclamation with the reduction of the parameters used to diagnose saline and alkali soils and improvement in the useful and beneficial soil microbial population to a large extent, which is not possible with the reclamation methods or management practices so far adopted in various countries.

Based on the results, especially of yield of rice crop, reproduced below, achieved with the two experiments conducted during 2000 & 2003, the present project is submitted to UN under the UN programme "International Network on Water, Environment and Health" for award of this project in which the latest EM Technology, a cost effective and environment friendly, will be used for reclamation of saline and alkali soils.

Comparison of Rice Yield under normal soils and on saline-alkali soils using EM Technology in the 1st year of reclamation

With & without EM Technology	Year of reclamation	No. of plants/ha	Yield/ha (kg)	Yield/plant (gm)
Under normal soils	Maximum average	197680	2965	15.0
Under saline-alkali soil	-do-	197680	2765	13.9
EM Technology Loamy soil	1st year 2000	197680	3682	18.62
EM Technology Silty clay soil	1st year 2003	197680	3783	19.13

Characteristics of Saline and alkali soils, comparison of various methods of reclamation and mechanism of reclamation with M Technology:

The possible chemical reaction taking place in alkali soils using gypsum and mechanism of M Technology to reclaim these soils is given below:

According to Diagnosis and improvement Saline and alkali soils, Agriculture Handbook No. 60, United States Department of Agriculture the salt affected soils are classified as given in the table below. The soluble cations and anions generally present in saline and alkali soils are Ca^{++}, Mg^{++}, Na^{+}, K^{+} (cations) and CO_3, HCO_3, SO_4, Cl (anions).

Soil type	**pH**	**EC_e** (mmhos/cm)	**Exchangeable Na**	**Amendment**
Saline soil	<8.5	>4	<15	Not required
Alkali soil	>8.5	<4	>15	Generally gypsum is used
Saline-alkali	<8.5 and 8.5 – 10	>4	>15	Generally gypsum is used

Possible chemical reactions in alkali soils during reclamation with gypsum

In case of reclamation of **saline soils** the salts become soluble in irrigation water and leach down to the lower soil profile layers. It takes longer period of 2–3 years for leaching down the salts and making the soil productive.

In case of **alkali soils** the purpose of using amendment (gypsum or H_2SO_4) is to replace Na^{+} with Ca^{++} from the clay complex. The reaction-taking place is given below:

$$2NaX + CaSO_4 \text{ (gypsum)} \_\_\_\_\_ CaX + Na_2SO_4$$

(X = Clay complex)

$$H_2SO_4 + CaCO_3 \_\_\_\_\_ CaSO_4 + CO_2 + H_2O$$
$$2NaX + CaSO_4 \_\_\_\_\_ CaX + Na_2SO_4$$

In case of EM application to start with 10 tons of FYM + PM (Farmyard Manure and Poultry Manure) /ha/year and 250kg Bokashi to rice and wheat crop are added besides the application of 120lit EM –1 with irrigation water and sprays. No commercial/inorganic fertilizers are added. Thus, 180kg N, 65kg P_2O_5 and 135kg K_2O are added to each crop during the 1st year. The EM Technology helps to maintain the:-

- increased beneficial microbial population in the rhizosphere
- enhanced decomposition of organic matter to release nutrients in the soil solution
- release of energy and organic acids such as amino, lactic, acetic, citric and butyric
- timely availability of macro and micro nutrients such as NPK, Ca, Mg, K, Cl, B, Mo, Fe, Mn, Zn and Cu to the plants
- physical properties such as water holding capacity, aggregation of soil particles and porosity
- reduction in pH of the rhizosphere with the application of compost of FYM + PM, Bokashi and M solutions having pH 6.5, 5.6 & 3.5 respectively, thus

uptake of nutrients by the crop is assured as maximum uptake takes place at about neutral pH

Besides this :-

- The organic acids, in the presence of large quantity of irrigation water (acidic medium), attain 100% dissociation [considerably weaker than N/10, Biochemistry in agriculture sciences Vol. II by S. S. Bhatia, pp 4.] produce not only a large quantity H-ions but also release Ca from the Ca CO_3 of the soil and Bokashi. The released H and Ca ions replace Na from the clay complex forming leach-able Na_2 SO_4.
- Photosynthetic bacteria has the characteristics to accept Cl from NaCl and produce protein
- Yeast contains Apo-protein-A & B which can convert NaCl into protein and chelates
- Salt tolerant bacteria has the characteristics to de-ionize NaCl in the soil

Thus, EM Technology combined with the application of FYM + PM and Bokashi replace Na with Ca from the clay complex besides increasing the population of beneficial and useful microorganisms in the soil and with that the soil fertility resulting in the reclamation of saline alkali soils and good yield in the 1st year.

Benefits of using EM Technology

The application of EM Technology is **time saving** (good yield can be obtained in the 1st year of reclamation), **cost effective** as compared to gypsum application (on an average US $ 271/ha and 475 with EM Technology and gypsum respectively), **less quantity and minimum transportation cost** (100 lit/ha EM –1 as compared to 20 tons/ha gypsum, thus corresponding transportation cost, which is much higher in case of gypsum), **easy to apply (**EM solution are to be applied with irrigation water with little arrangement of EM containers but in case of gypsum extra labour is require), and **environment friendly** (handling of EM Technology is friendly at all levels as compared to gypsum and especially sulfuric acid, which is extremely dangerous.)

Project implementation

a) **Phasing of the project**

To achieve the objectives it will take a period of 3 years to complete the project and to bring the reclaimed soil to the level of normal good productive soil. The phasing of the project is detailed below"

Phase-I: Preparation and arrangement of requisite material

The chemical characteristics and physical properties of saline and alkali soil will be studied first of all to determine the exact dozes of EM Technology. Arrangements will have to be made for the followings:-

- **i)** Supply of Farm Yard Manure (FYM) and Poultry Manure (PM) and preparation of compost with EM Technology,
- **ii)** Purchase of EM-1 concentrates,
- **iii)** Purchase of plastic containers of different sizes for the preparation of Microbial solutions and their storage,
- **iv)** Purchase of rice bran and sugar cane molasses for the preparation of Bokashi (rice bran fermented with EM Technology, a type of organic manure rich in micronutrients),
- **v)** Purchase of spraying equipments for microbial sprays,
- **vi)** Purchase of seed for rice and wheat as per season,
- **vii)** Purchase of other minor equipments,
- **viii)** Irrigation water (canal or tube-well and determination of its quality),
- **ix)** Tractor for cultivation,
- **x)** Labor etc.

Phase-II: Carrying out of experiments

After the completion of phase-I, experiments will be undertaken with predetermined dozes of various types of EM material on different kind and type of saline and alkali soils as per requirements and facilities of transportation. The results of the experiments and the soil analysis data will help to conclude the level of reclamation achieved in the 1st year and subsequently years to bring the reclaimed soil to a normal good productive soil.

Phase- III: Calculation of Economics of Reclamation

The 3 years duration of the experiments conducted on various types of saline and alkali soils will help to calculate the economics of reclamation with EM Technology.

b) Monitoring and evaluation of targets to be achieved during the project implementation period

EM Research Organization Officers will perform the duties of monitoring and evaluation regularly in collaboration with UN Officers so that the targets of the project are completed as per schedule.

c) Soil analysis and rice/wheat grain analysis

Soil samples taken from the original saline and alkali experimental soil before and after the 1st rice crop, after the wheat crop in each year and samples of rice/wheat grains of each year shall be got analyzed from a reputable laboratory.

d) Interim and final reports

Based on the results of 1st year, 2nd year and 3rd year interim reports, annual reports and final report will be prepared and submitted in time.

Expectations

Under the umbrella of UN Programme it is expected that authenticated but positive results will be obtained with a 3 years experiment on the reclamation of saline and alkali soils documented with soil and grain analysis.

Achievements made or expertise of EMRO, Regional Office, Lahore, Pakistan

Achievements

- EMRO, Lahore, Pakistan has completed pilot research project "conversion of petroleum sludge into useful bio-fertilizer" in the petroleum industry in collaboration with UNIDO-NCPC at Attock Refinery Limited (ARL), Rawalpindi, Pakistan. The highly polluted sludge of ARL was treated with EM Technology, converted into biosludge within a period of 8 weeks, mixed with equal quantity of soil to change its oily nature and applied to onion crop. The concentration of heavy metals (Ba, Pb, Fe, Zn, Ni, Mn, Cu, Cr, As) were reduced from 38 to 93% in the sludge and later on in the biofertilizer applied to onion crop with EM irrigations and sprays. The concentration of heavy metals in the onion crop were far less than the limits given by FAO and Food Technology Standards.
- EMRO, Lahore, Pakistan has completed pilot research project "treatment of tannery effluent and sludge in the leather industry" in collaboration with Pakistan Tanners Association and NEC. The heavy metals especially Cr was reduced from 50,000 ppm to 230 ppm in the effluent and sludge. Later on the sludge was applied to rice crop. A good yield was obtained and the concentration of Cr was within the limits prescribed by FAO and Food Technology Standards.
- EMRO, Lahore, Pakistan in collaboration with NUST-NC-Consulting (National University of Science & Technology), Islamabad has submitted projects for the treatment of sewage water, industrial effluent & sludge, city solid waste with EM Technology to the Government of Pakistan.

These are under consideration by the concerned Ministry of Government of Pakistan.

-EM Research Organization, **Lahore, Pakistan**.

Expertise:

EMRO, Regional Office, Lahore, Pakistan has the expertise in the Bioremediation of Petroleum Waste, Leather Industry Waste, City Solid Waste Treatment & Management, and reclamation of saline and alkali soils with EM Technology.

Project at hand

A project on "the treatment of effluent and sludge of Leather Field Sialkot" was submitted to UNIDO-UNDP, Islamabad. The same was approved during May 2004 as a UNIDO-EPA, Pakistan by the Ministry of Environment, Islamabad and Punjab Government. Under the project the effluent and sludge is to be treated with EM Technology to eliminate the pollutants in both the wastes for their safe disposal and beneficial use in the field of agriculture, floriculture and horticulture. The implementation of the project will be taken up as soon as the budget is released.

Estimated project budget **Rs. 4.0 million**

i) Employment of manpower:

Description	Nos.
1. Project execution and completion services by EMRO experts	2
2. Field assistant	1
3. Laborers	2
4. Watchman	1

ii) Estimated budget (items of expenditures)

Item	COST
a) Purchase of equipments and machinery • Purchase of plastic containers of 1 ton, ½ ton, ¼ ton capacity and spraying equipment • Purchase of EM –1 and molasses /ha/year • Purchase of FYM & PM/ha/year for rice and wheat crop at site in the 1st year • Purchase of Bokashi/ha/year • Purchase of seed for rice and wheat during the 1st year /ha • Rent of land/ha/year • Rent of tractor for the preparation of land etc /ha/year • Hiring of laboratory facility/year **b) Salary** • 2 EMRO experts (Rs. 30,000/= per month each for 1 year) • 1 Field Assistant (Rs. 6,000/= per month for 1 year) • 2 Laborers (Rs. 4,500/= per month each for 1 year) • 1 Watchman (Rs. 4,500/= per month for 1 year) **c) Other expenditures** • Transport on rent for 1 year as and when required • Miscellaneous (transplantation of rice nursery, sowing of wheat, harvesting and threshing of rice and wheat etc.)	**As per prevailing rate.**