*As per UGC guidelines an electronic bar code is provided to seure your paper*

*International Journal for Modern Trends in Science and Technology*
*Volume 10, Issue 04*, pages 71-76.
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol10issue04.html
DOI: https://doi.org/10.46501/IJMTST1004012

# Role of Pyrite in Sodic Soil Reclamation: A Review

**Dr. Dhirendra Singh**

Principal, Govt. Girls PG College, Sawaimadhopur-322001, Rajasthan, India

**To Cite this Article**
Dr. Dhirendra Singh, Role of Pyrite in Sodic Soil Reclamation: A Review, International Journal for Modern Trends in Science and Technology, 2024, 10(04), pages. 71-76.https://doi.org/10.46501/IJMTST1004012

**Article Info**
Received: 20 March 2024; Accepted: 06 April 2024; Published: 08 April 2024.



## ABSTRACT

***Among the soil amendments, pyrites and gypsum is most commonly used for soil reclamation. The requirement of amendments per unit area depends on the nature and degree of soil deterioration, texture and other soil properties.***

*KEYWORDS-pyrite, gypsum, reclamation, sodic, soil*

## 1. INTRODUCTION

Out of several productive hazards, soil alkalinity, was one of the major problem in the district. The extent of sodic soils were estimated by 1.21 lacs ha out of which 44,000 ha was badly affected (9.5 to 10.5 pH range). Most of the affected areas were under the ownership of village panchayats which have been leased out to the landless families of the village, who have meager resources. High cost of reclamation, lack of physical and financial resources, unawareness, low level of knowledge and hesitant to resistant behavior against reclamation were some of the major constraints in reclamation and utilization. The vision and aim of the KVK was to manage such type of land by linking with different organizations/departments to transform the area by facilitating for technical, physical and financial resources. In this context, KVK has implemented and Operational Research project on alkali reclamation sponsored by Indian council of Agricultural Research, during the period of 1985-86 to 1991-92 with following objective [1,2,3]

To test, adopt and demonstrate the reclamation technologies and their suitability in local condition.

To determine the profitability of recommended technologies and their pace of adoption among the farmers.

To identify the constraints both technological and socio- economical which serves as barriers for adoption among the farmers, and

To demonstrate group action as method for popularizing the modern technologies at faster rate.

**Project Activities :**

On the basis of above objectives, the activities have been performed through

Large scale demonstration on reclamation technologies by motivating, mobilizing and upgrading the knowledge and skill of the farmers under operational area.

Conducted on – farm trials on different technical aspects, to find out their suitability and adoptability among the farmers.

Organising field days and exhibitions for dissemination of viable technologies organizing field days and exhibitions for dissemination of viable technologies among larger group of farmers of the area, facilitating them by linking with other developmental agencies and departments of district for financial and input support, and

Observing the constraints emerges during the programme implementation as well as the adoption of technologies among the farmers.

Characteristics of the soil :

The salt affected soils of the district was characterized by Deposition of white or white – grayish powder on the surface of soil during dry period of the year.

pH of the soil was high and ranges up to 10.5 and above.

Available salts were predominated by sodium carbonate and sodium bicarbonate.

Presence of hard- pan were observed throughout the soil profile at a depth of 60 – 120 cm. With different size and density of kankars (caco3). The soil was highly depressed and have poor physical properties, resulting in restricted water and air movements.

Water table varies from 6-8 m and underground water was of good quality at every locations.

Devoid of vegetations for presence of Sporobollus species, Beuteamonosperma or some abnoxious busses.[4,5,6]

**Implementation of the programme :**

The programme was implemented in collaboration with agriculture department and District Rural Development Agency, Sultanpur with active participation of farmers of the operational area. During the implementation, following components have been taken up on priority basis

**Socio-Economic component :**

Motivation and mobilization of farmers for active participation.

Involvement in decision making.

Linkages with development departments for financial and input support, installation of tubewells and other income generating activitie to improve family income.

**Technical component :**

On – farm development, like bunding, leveling, ploughing, creation of drainage facilities and irrigation channels, soil sampling, treatment of soil etc.

Use of alternative measures for reclamation to minimize the cost.

Use of salt tolerant crops, feasible cropping pattern and improved crop management practices.

Use of salt tolerant tree species of fruits and forestry, varieties of fruit crops, age of saplings and optimization of plant density.

Agro – techniques fro creation of favorite atmosphere to the root zone for young saplings which includes optimum pit size and pit preparation, use of filling mixture, pit condition for planting, water and nutrient management, training and pruning etc.

**Priority of Enterprises :**

The first priority was given to the crop production by the farmers followed by fruits and forestry plantation. The community land of operational area was covered under forest trees, whereas, low lying area and old ponds were developed for fish culture.

The majority of the farmers were of the view that sodic soils can not be reclaimed. Thus, the famers of the operational area were persuaded, motivated and mobilized through frequent meeting. The village leaders, block and village level functionaries as well as district authorities were also involved in the process. The technological efficacy of alkali reclamation has been successfully demonstrated and trials were conducted on their own fields to break their resistant behaviors during the period of 1985-1994 and 1,551 farmers of 23 villages have been benefitted by covering an area of 695 ha under crop production and 204 ha under fruit and forestry plantation.

The recommended technologies related to crop production and plantation have been also modified according to available resources of the area. The outcome of the experiences and feasible technologies were disseminated among larger group of farmers through training, organizing kisan mela and field days in the adopted villages.[7,8,9]

## 2. DISCUSSION

Reclamation and Crop Production

As the crop production was the priority area of lease holders, small and marginal farmers of the operational area, therefore, emphasis was given to this enterprise to fulfill the immediate need and early income. The results obtained from large number of demonstration and on-farm trials, full confidence was developed among the farmers. They have also accepted that, salt affected soil can be reclaimed successfully by adopting the agro-techniques. Depending upon the findings, following essential components of the technology have been recorded for achieving success in the reclamation and crop production in sodic soils.

**On - Farm Development :**

Proper land leveling and bunding is pre requisite for uniform leaching of salts and application of water for irrigation. The unleveled plots shows patchy effect and crop grown in such plots do not perform well due to accumulation of salts in depressed area.

**Drainage :**

Drainage is the most essential part of the alkali reclamation. Therefore, good surface drainage systems comprises field drain, sub-drain should be developed before reclamation.

**Provision of irrigation :**

Quality water is prerequisite for leaching of salts and crop production Therefore, assured irrigation through bore well is more beneficial than irrigation through canal system. The bore wells have also ensured in time availability as well as substantially keeps the ground water table at reasonable depth.

**Application of soil Amendments :**

Among the soil amendments, pyrites and gypsum is most commonly used for soil reclamation. The requirement of amendments per unit area depends on the nature and degree of soil deterioration, texture and other soil properties. However, it has been concluded that 50% of the total gypsum requirement is sufficient to improve the soil for crop production. Here, it has been also clearly observed that combined effect of organic materials and gypsum proves more effective in terms of cost and productivity.

Application of amendments in powder form upto 10 cm depth proved to be more effective in comparison to application of clots at lower depth. Addition of organic matter in the form of FYM. Green manures, water hyacinth, press mud of sugar mill or any other agricultural wastes available on cheaper rats helps in improving soil structure, aeration and also encourages micro-biological activities and crop growth.[13,14]

Crops and Cropping Pattern :

Proper choice of crops and its varieties tolerant to salts is more important to ensure reasonable return during the initial phase of reclamation. Thouth, it is well established that rice-wheat crop rotation is found to be most economical at early stage. In general, those crops which are able to withstand excess moisture condition can also be grown successfully in reclaimed soil. In rice—wheat rotation, short to medium duration varieties of rice like Saket-4, Sarju- 52, CSR-10 Pant-6 ,Pant -10 etc. were more effective than long duration salt tolerant high yielding varieties like, Usar- 1 and NDR -501. Among the wheat varieties, K -7410, UP -2003, HD -2285, UP -262, Lok -1, Snalika; barley varieties Amber, Jyoti and Vijai; mustard varieties, Varuna, Rohini and NDR -8501 and barseem can be grown successfully in Rabi. As for as vegetable crops spinach for seed production was found most suitable crop followed by onion seed production and suger beet as fodder crop.

Paddy seedlings should be raised in normal soil. The seedlings of rice used for planting should be 30-35 days old with increased number of seedling (3-5 plants) per hill at a distance of 15 cm apart. Gap filling must be ensured within seven days after transplanting to maintain the optimum plant density.

Water Management :

Due to poor water transmission characteristics of the alkali soil, care should be taken for water management specially in wheat. Light and frequent irrigation proved to be more useful than heavy irrigation at long intervals.

**Inter culture Operation :**

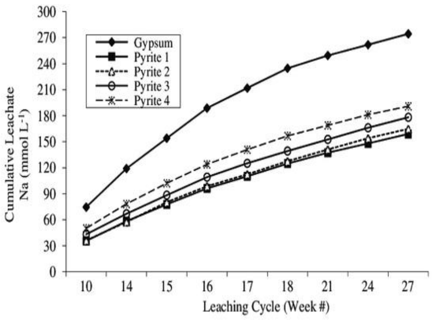
One inter culture operation in wheat after first irrigation proved to be more use full, because it helps in soil aeration, on yield of wheat grain (q/ha) in reclaimed alkali soil.

**Regular Cultivation :**

The land once reclaimed for crop cultivation should not be kept fallow otherwise, tha land will reverse in its original condition.[15]

**Dissemination of Reclamation Technologies :**

Obviously, the transfer of technology related to sodic land reclamation looks very simple but its implementation at gross – root level is more difficult and complex. Under the present agricultural extension system it is necessary to improve the knowledge and skill of the farmers as well as village level extension functionaries for effective implementation and dissemination of viable technologies as per needs of the local situation. Therefore, priority was given for periodical training, conducting demonstration, trials on famer's field, organization of field day and frequent meeting with the farmer and extension functionaries in the operational area.




A field experiment was conducted to investigate the effect of pyrite in reclamation of degraded calcareous soils. In this paper, the behaviour in soil of Cu, Zn, Fe and Pb was studied, 3a after application of 4 rates of pyrite (0, 3, 6 and 9 t ha−1) and of 3 rates of superphosphate (0, 76.5 and 153 kg P ha−1). Total Cu, Zn, Fe and Pb and DTPA extractable Cu, Zn, Fe increased linearly with the amount of applied pyrite. After 3a, most of the Cu, Zn, Fe and Pb remained attached to the pyrite. In the treatment with 9 t ha−1 of pyrite only Zn occurred at concentrations which might cause environmental problems.

The reclamation of alkaline soils is of great interest especially in arid and semi-arid climatic regions of the world. The aim of this study was to investigate the application of pyrite from the waste materials of a copper concentration plant as an alternative to gypsum application for alkaline soil amelioration. The second aim was to assess heavy metal contamination. Waste pyrite (FeS2) obtained from a copper concentration plant and pure gypsum (CaSO4 center dot 2H(2)O) were added to soil within the columns and pots. Column-leaching tests were performed to determine the effectiveness of waste pyrite application on alkaline soil characteristics as compared with gypsum application. Greenhouse pot experiments were also conducted for evaluating the effects of these soil additives on plant growth. The results indicated that the pH and exchangeable sodium percentage of the experimental soil significantly decreased ($p < 0.01$) upon waste pyrite and gypsum applications. While waste pyrite was very effective in increasing the levels of essential plant micro-nutrients and dry matter weight of wheat, it did not cause pollution or toxicological problems in the soil. The results of this study clearly indicated that waste pyrite is a good ameliorating agent and an alternative to gypsum in reclamation of alkaline soils.

## 3. RESULTS

A field experiment was conducted in a sodic soil (Typic Halaquepts) of Kanpur, India, to explore possibilities of utilizing coal fly ash for the purpose of reclamation. Effectiveness of coal fly ash applied at the rate of 10 and 20 Mg ha-1 on changes in physicochemical properties of soil and its ultimate effect on the yields of rice IR-8 and wheat Sonalika grown in a sequence were evaluated. Changes in soil pH, electrical conductivity, Na saturation % of exchange complex, hydraulic conductivity, bulk density, stability index, and moisture retention characteristics were monitored after harvest of each crop. Results indicated that coal fly ash was effective for improving physicochemical properties of sodic soil, which in turn resulted in significant increase of yields for rice and wheat. Application of fly ash at the rate of 10 and 20 Mg ha-1 improved paddy rice yields from 1.02 (control) to 2.85 and 3.38 Mg ha-1 during 1979, and from 1.98 to 4.03 and 4.65 Mg ha-1 during 1980, respectively. Similarly, wheat yields were improved from 0.57 (control) Mg ha-1 to 2.40 and 2.53 Mg ha-1 during 1979–1980, and from 1.17 (control) to 2.75 and 2.85 Mg ha-1 during 1980–1981 by application of fly ash at the rate of 10 and 20 Mg ha-1 respectively. Pyrite proved more effective than fly ash. The pH of the soil, its soluble salt content, and Na saturation % of the exchange complex considerably decreased. The initial soil pH of 10.0 was reduced to 8.3 and Na saturation % dropped from 64.5 to 24.0 after application of amendments. Soil bulk density (1.51 Mg m-3) exhibited a well-marked decrease, while hydraulic conductivity (0.55 mm h-1) and stability index (15.88) improved considerably by application of fly ash and pyrite. Initial average values observed for bulk density, hydraulic conductivity, and stability index of the soil were 1.56 Mg m-3, 0.076 mm h-1, and 12.4, respectively.[16,17]

In many sodic soils sodicity originates from the nature of the parent material and pedogenic processes. There are also sodic soils where sodicity arises from anthropogenic processes (human activity), and this is termed secondary sodification. Irrigation with sodic water or without proper drainage, forest clearing, and other land management practices that lead to water logging are key activities that may yield rapid secondary sodification. The total area worldwide of sodic soils is estimated at 210 million ha. The area of sodic soils in each continent and in some countries where they form an important proportion of the soils

The spatial distribution of sodic soils indicates that they occur in a range of climates. However, the outlined distribution of sodic soils and the conditions promoting their formation are based on a pedological approach. Following the increase in the contribution of human activity to soil sodification, the definition of sodic soils is now based on soil behavior. Many agricultural soils that exhibit sodic behavior may not fit into the classical sodic soil group. Consequently, the sizeable area these soils cover remains unaccounted for.

Saline and sodic soils exist in arid and semiarid regions and in regions of poor natural drainage. These soils have poor physical properties owing to high sodicity and high pH. Under these conditions, slow water infiltration into the soil, soil erosion, slow internal drainage, poor aeration, compaction, and waterlogging on lower lands commonly occur due to soil swelling and dispersion.

Considerable progress has been made in managing and controlling salinity, sodicity, and alkalinity in irrigated lands. However, because of natural hydrological and geochemical factors, as well as irrigation-induced activities, soil salinity, sodicity, alkalinity, and associated drainage and soil erosion continue to plague agriculture. Control of salinity and sodicity is essential to establish a sustainable, successful agriculture.[18,19]

CONCLUSION

The productivity of sodic soils is limited, mainly because of the deterioration in their physical properties, which causes poor aeration, restricts root development and enhances root diseases. However, the impact of Na on soil productivity may also depend on crop tolerance to Na per se and plant nutrition in Na-affected soils. A detailed review on nutrient constraints in Na-affected soils is presented in Qadir and Schubert (2002).

Plant species are characterized as 'natrophilic' or 'natrophobic,' depending on their growth response to Na and their capacity to take up Na by roots and transport it to shoots (e.g., Phillips et al., 2000). The role of Na in plant nutrition in different species is: (i) essential for certain plant species, (ii) replacing K functions in plants at different concentrations, and (iii) a beneficial element enhancing growth (Broadley et al., 2012). Growth of many halophytes, whether C3 or C4 species, is enhanced by large Na concentrations in the substrate (generally, 10–100 mM Na, but up to 510 mM Na in extreme cases; Redondo-Gomez et al., 2010). However, the majority of commercial crops are defined as non-halophytes (glycophytes), therefore such large Na concentrations are not required. Sodium is not essential for C3 species but it is an essential micro-nutrient for many, but not all C4 species. In general, the concentration of Na in the soil solution of the majority of agricultural soils is much higher than that required for C4 species. Sodium was found as a proxy for K and can replace it under low K availability in several herbaceous plants (Kronzucker et al., 2013) and fruit trees (e.g. olives, Erel et al., 2014)

Large Na concentrations were found to be toxic to many glycophytes plants, where the predominant effect of the co-presence of $Na^+$ in $K^+$-containing media is one of affecting $K^+$ homeostasis negatively. More detailed description of the various aspects of sodium toxicity are presented in the review by Kronzucker et al. (2013). Typical symptoms of sodium toxicity are necrotic spotting in the leaves, followed by the development of a marginal necrotic band.[20]

**Conflict of interest statement**

Authors declare that they do not have any conflict of interest.

**REFERENCES**


[1] Warr, L.N. (2021). "IMA–CNMNC approved mineral symbols". Mineralogical Magazine. 85 (3): 291–320. Bibcode:2021MinM...85..291W. doi:10.1180/mgm.2021.43. S2CID 235729616.

[2] ^ c Hurlbut, Cornelius S.; Klein, Cornelis (1985). Manual of Mineralogy (20th ed.). New York, NY: John Wiley and Sons. pp. 285–286. ISBN 978-0-471-80580-9.

[3] ^ "Pyrite". Webmineral.com. Retrieved 2011-05-25.

[4] ^ "Pyrite". Mindat.org. Retrieved 2011-05-25.

[5] ^ Anthony, John W.; Bideaux, Richard A.; Bladh, Kenneth W.; Nichols, Monte C., eds. (1990). "Pyrite" (PDF). Handbook of Mineralogy. Vol. I (Elements, Sulfides, Sulfosalts). Chantilly, Virginia, US: Mineralogical Society of America. ISBN 978-0962209734.

[6] ^ "Pyrite | meaning in the Cambridge English Dictionary". dictionary.cambridge.org.
[7] ^ Vernon J. Hurst; Thomas J. Crawford (1970). Sulfide Deposits in the Coosa Valley Area, Georgia. Economic Development Administration, Technical Assistance Project, U. S. Department of Commerce. p. 137.
[8] ^ Jackson, Julia A.; Mehl, James; Neuendorf, Klaus (2005). Glossary of Geology. American Geological Institute. p. 82. ISBN 9780922152766 – via Google Books.
[9] ^ Fay, Albert H. (1920). A Glossary of the Mining and Mineral Industry. United States Bureau of Mines. pp. 103–104 – via Google Books.
[10] ^ πυρίτης. Liddell, Henry George; Scott, Robert; A Greek–English Lexicon at the Perseus Project.
[11] ^ πῦρ in Liddell and Scott.
[12] ^ Dana, James Dwight; Dana, Edward Salisbury (1911). Descriptive Mineralogy (6th ed.). New York: Wiley. p. 86.
[13] ^ "De re metallica". The Mining Magazine. Translated by Hoover, H.C.; Hoover, L.H. London: Dover. 1950 [1912]. see footnote on p 112.
[14] ^ "Armor-plated snail discovered in deep sea". news.nationalgeographic.com. Washington, DC: National Geographic Society. Archived from the original on November 10, 2003. Retrieved 2016-08-29.
[15] ^ Fleet, M. E.; Mumin, A. Hamid (1997). "Gold-bearing arsenian pyrite and marcasite and arsenopyrite from Carlin Trend gold deposits and laboratory synthesis" (PDF). American Mineralogist. 82 (1–2): 182–193. Bibcode:1997AmMin..82..182F. doi:10.2138/am-1997-1-220. S2CID 55899431.
[16] ^ Larson, Bruce (2003). "Firearms". An Interpretation of Firearms in the Archaeological Record in Virginia 1607-1625. Dissertations, Theses, and Masters Projects. Vol. 1. pp. 413–418.
[17] ^ Schultz, Chester (22 October 2018). "Place Name Summary 6/23: Brukangga and Tindale's uses of the word bruki" (PDF). Adelaide Research & Scholarship. University of Adelaide. Retrieved 16 November 2020.
[18] ^ "Industrial England in the Middle of the Eighteenth Century". Nature. 83 (2113): 264–268. 1910-04-28. Bibcode:1910Natur..83..264.. doi:10.1038/083264a0. hdl:2027/coo1.ark:/13960/t63497b2h. S2CID 34019869.
[19] ^ Rosenqvist, Terkel (2004). Principles of extractive metallurgy (2nd ed.). Tapir Academic Press. p. 52. ISBN 978-82-519-1922-7.
[20] ^ "Cylindrical Primary Lithium [battery]". Lithium-Iron Disulfide (Li-FeS2) (PDF). Handbook and Application Manual. Energizer Corporation. 2017-09-19. Retrieved 2018-04-20.