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Sustainable Agriculture: Evaluating the Potential of Desalination Waste from Salt-pans Versus Solid Fertilizer Prepared from Saline Commodities

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ABSTRACT

Common salt is one of the most plentiful substances on earth. It is an important raw material in various industrial applications including chemical production, water treatment, food processing etc. It is a major compound for humans as it plays a significant role in our physiological activities. So, understanding salt-pans and their quality is crucial for utilizing solar salt-pans for human welfare. Solar evaporation technique for salt production has been a traditional source of wealth since ancient times, which utilizes brine from seawater, backwater, subsoils etc. Bittern, a by-product of desalination activities, can significantly harm marine life and the environment. One of the important sources for the synthesis of magnesium-based fertilizers is the bittern, which is an unavoidable toxic material, from solar saltpans after crystallizing common salt. Unwanted agricultural practices deplete farmlands, necessitating soil fertilizer addition for soil fertility. Solid fertilizers prepared through various improved methods using this harmful toxic substance bittern, provides balanced nutrients like sodium, iron, calcium, potassium, magnesium, and trace elements. Sustainable management of bittern is a global priority due to incorrect disposal and unknowing the benefits of it as a highly effective fertilizers in magnesium demanding crops.

***Key words*:** Common salt, Salt production, Salt-pan, Brine, Bittern, Fertilizer

Common salt is one of the most plentiful substances on Earth because it is found in vast quantities both in the oceans and in underground deposits. Seawater contains about 3.5% salt by weight, making the oceans an almost inexhaustible source. Additionally, large natural salt deposits, formed from ancient evaporated seas, exist in many parts of the world. These abundant sources ensure that salt is readily available and can be produced on a massive scale through mining and evaporation methods [1]. During solar salt production, large quantities of bittern, a liquid by-product containing high inorganic substance concentrations, are produced [2]. During the process of solar salt production, where seawater is evaporated using sunlight to extract common salt (sodium chloride), large quantities of bittern are generated as a by-product. Bittern is the residual liquid that remains after most of the sodium chloride has crystallized and been removed. This liquid contains very high concentrations of inorganic substances such as magnesium, calcium, potassium, and sulfates. Because these substances do not crystallize as easily as sodium chloride, they accumulate in the bittern, making it highly concentrated and chemically active. The management and disposal of this by-product are critical, as its high mineral content can pose environmental risks if released untreated into surrounding ecosystems [3]. Usually, the salt workers dispose them as a waste material. The purpose of this research is to examine the utilization of waste bittern generated from salt-pans as a source for magnesium fertilizer. Bittern, a by-product of desalination activities, can significantly harm marine life and the environment because it is a highly concentrated brine that remains after freshwater has been extracted from seawater. This residual solution contains high levels of salt and other chemicals, such as heavy metals and treatment residues, which can increase the salinity and toxicity of surrounding marine ecosystems when discharged back into the ocean. The sudden change in water composition can disrupt the natural balance, harming or killing marine organisms, affecting biodiversity, and potentially damaging coral reefs and seagrass beds. Over time, repeated discharge of bittern can degrade the overall health of marine habitats and threaten the

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livelihoods of communities that depend on them [4]. Bittern is a bitter-tasting solution formed from sodium chloride evaporation and crystallization. It is a concentrated form of magnesium, potassium, sulphate, and chloride salts, such as KCl, $MgCl_2$, $MgSO_4$, and double salts, which are good source of fertilizers [5]. The present article relates to a process, methods and materials for generating solid fertilizers from brine resources, especially in conjunction with bittern from salt-pan. In the present study, it has been shown that varying compositions of fertilizers such as nitrogen-potassium, nitrogen-phosphorus-potassium, nitrogen-potassium-sulphur, and nitrogen-phosphorus-potassium-sulphur, potassium-sulphur, potassium along with micro and secondary nutrients can directly be generated as part of the extraction process to meet the requirements of both starter and sustained phases of growth in magnesium demanding plant like green chillies.

MATERIALS AND METHODS

Bittern samples were collected from Swamithoppu Salt-pan of Kanyakumari district. These samples were subjected to chemical treatment with different chemicals by adopting different methods. One such method utilized for the preparation of different fertilizer is used in this work to study the progress of growth of Surinum spinach.

Method for the preparation of solid fertilizer

To 10 ml of bittern in a 250 ml conical flask added 10 ml of NH_4OH. To this mixture 25 ml of saturated solution of ammonium phosphate was added and stirred vigorously for one hour. The combined extract was washed, dried and weighed. The fertilizer value of bittern was studied by analyzing the biomass production of magnesium-demanding Surinum spinach and its impact on solid fertilizer concentration in different pots.

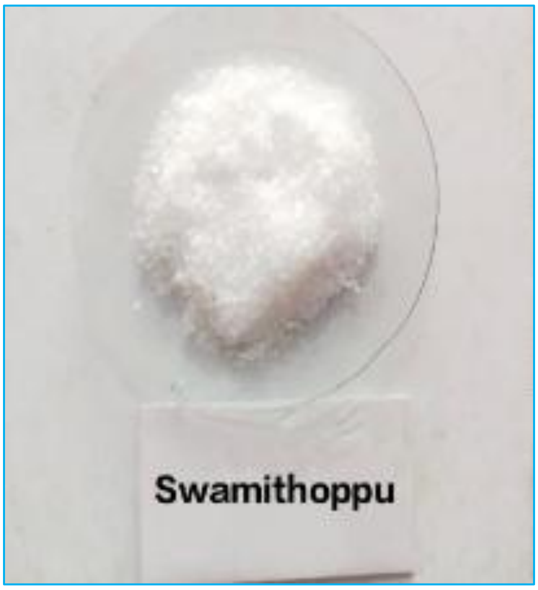


Fig 1 Solid fertilizer prepared from Swamithoppu salt-pan

Experimental set-up

The pots were uniformly sized, measuring 1 feet in height and 30 cm in width. The soil, sand, and organic mixture were mixed in a 1:1:1 ratio and filled 3/4th in all pots. The experimental setup was maintained on an open terrace to ensure uniform sunlight exposure for all pots. In each pot, seeds were sown and watered daily in the morning and evening. The number of days for germination was even in all the five different pots and the entire experiment was carried out for ninety days. The height, total number and yield of fruits, maximum leaf width and total number of leaves in the plants of the five different pots were recorded. A dilute metacid (2ml in one litre of water) solution was applied using a hand-sprayer once every fifteen days to eliminate harmful pests. Throughout the study, the sprouting of flowers and enlarging of leaves were not uniform in all the five pots. The total number of leaves were recorded on the 91st day.

Ash analysis

The well-matured leaves of the plants were carefully cut off and dried at room temperature for 3 to 4 days. Of the dried leaves, 3 gm of each was weighed and further dried in an oven at a temperature of 110º −140ºC and were made into ash in silica crucibles. The ash of the five different samples was then digested with triple acid i.e., HNO_3, H_2SO_4 and $HClO_4$ in the ratio 7:2:1. The contents in the crucibles were heated in sand-baths and were made up to 25 ml in S.M Flask with double distilled water [6]. The five different samples were subjected to various analysis viz., percentage of calcium, magnesium, potassium, iron, manganese, zinc and copper by standard methods.

RESULTS AND DISCUSSION

The solid fertilizers that were prepared using different methods are presented in (Fig 1). These fertilizers were added to a magnesium-demanding crop like Surinum spinach. The observed growth of plants in various pots are presented in (Fig 2). The amount of various nutrients like potassium, calcium, manganese and zinc present in the plants were also studied.

Comparison of the fertilizer value of bittern and solid fertilizer

For the comparative study of fertilizer value of bittern and solid fertilizer, the growth of Surinum spinach plants was studied. The influence of these on growth were studied by growing the plants in different pots.

Three pots were used and labelled as:

- S-Control- Surinum spinach alone
- S-B- Surinum spinach with soil mixture and 20ml bittern evenly mixed
- S-SF- Surium spinach with soil mixture and 10g of solid fertilizer evenly mixed

First monitoring on 16th day

The sprouting of plant in all the three pots were uniform, i.e., on the 10th day. In S-Control a minimum plant height of 6.8 cm was observed and in S-B a height of 8.4 cm was observed. A maximum plant height of 10.1 cm was observed in S-SF.

Second monitoring on 31st day

In S-Control, a minimum plant height of 12.3 cm was observed and S-B had the plant height of 14.8 cm. S-SF had the maximum plant height of 17.7 cm.

Third monitoring on 46th day

The plant height increased gradually from S-Control to S-SF. In S-Control, the plant height was minimum and it was observed as 14.2 cm. S-B had the plant height of 16.7 cm. The plant height was maximum in S-SF and it was found to be 20.9 cm.

Fourth monitoring on 61th day

The plant height in S-Control was minimum and was 16.7 cm. S-B had the plant height of 20.9 cm. S-SF had maximum plant height of 25.5 cm.

Fifth monitoring on 76th day

In S-Control, a minimum plant height of 18.3 cm was observed. S-B had the plant height of 23.4 cm. S-SF had maximum plant height of 30.6 cm.

Sixth monitoring on 91th day

The plant height increased gradually from S-Control to S-SF. In S-Control, a minimum plant height of 20.8 cm was observed and S-B had the plant height of 26.2 cm. Maximum plant height of 38.9 cm was observed in S-SF.

Table 1 Surinum Spinach: Measurement of plant height (cm)

Classification	Day 16	Day 31	Day 46	Day 61	Day 76	Day 91
S-Control	6.8	12.3	14.2	16.7	18.3	20.8
S-B	8.4	14.8	16.7	20.9	23.4	26.2
S-SF	10.1	17.7	20.9	25.5	30.6	38.9

Fig 2 Variation in the growth of plants

Ash analysis

Ash samples from the three different pots were analyzed for various parameters. A gradual increase in the values of all the secondary nutrients and micronutrients from S-Control to S-SF was observed (Table 2).

The percentage of potassium was found to increase marginally from S-Control to S-SF. S-Control had a minimum value of 2.36%. For S-B it was found to be 2.98% Maximum value of 3.14% was observed for S-SF. From the earlier observations, it was known that the sufficient requirement of potassium for Surinam spinach was 2.50 to 3.50 % (Table-3). S-Control had the minimum value of calcium i.e., 0.49% and for S-B it was 0.68%. A maximum value of 0.84% was observed for S-SF. From the earlier observations, it was learnt that the sufficient requirement of calcium for Surinam spinach is 0.70 to 1.21 % (Table 3, Graph 1).

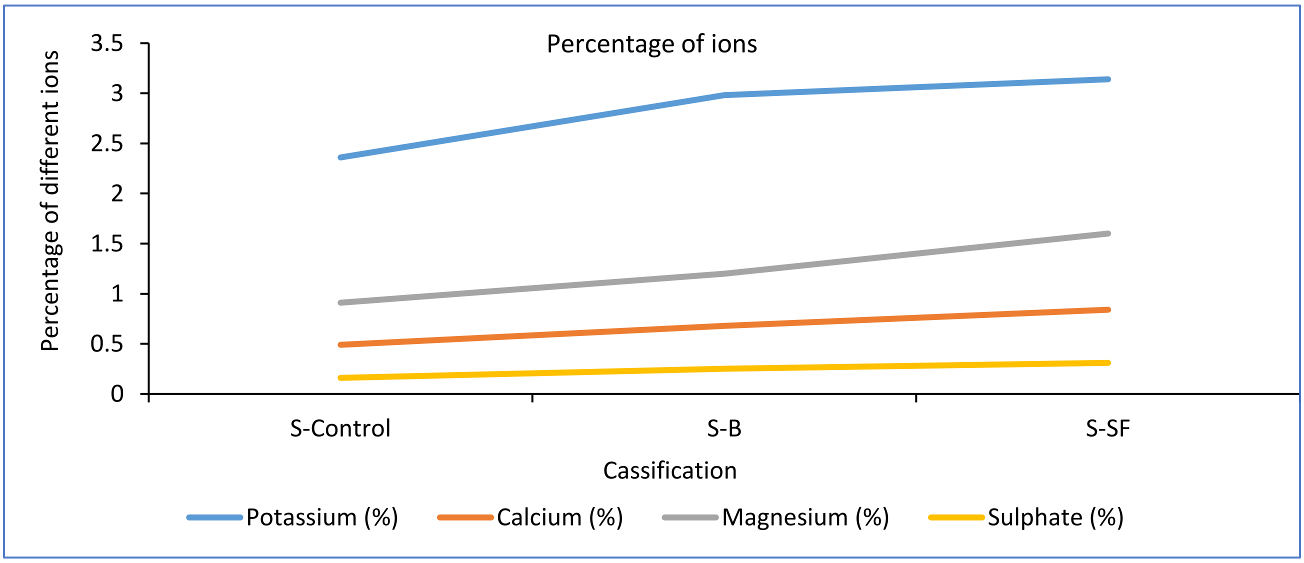
The percentage of magnesium was found to increase significantly from 0.91 to 1.6%. S-Control had the minimum percentage of magnesium i.e., 0.91%. But for S-B it was 1.2% and a maximum value of 1.6% was observed for S-SF. These values were found to correlate with the earlier observations, that 1.0 to 1.60 % of magnesium is sufficient for Surinam spinach. S-Control had minimum percentage of sulphate i.e., 0.16% and for S-B it was found to be 0.25%. S-SF recorded the maximum percentage of sulphate i.e., 0.31%. The above results were in agreement with the earlier observation that 0.20 to 1.0 % of sulphate is sufficient for Surinam spinach (Table 3, Graph 1).

The trace metals present in the five different samples were also analyzed and a marginal increase was observed from S-Control to S-SF. S-Control had minimum value of iron, i.e., 61 ppm and for S-B it was 69 ppm. Maximum value of 75 ppm was observed for S-SF (Table 2, Grap 2).

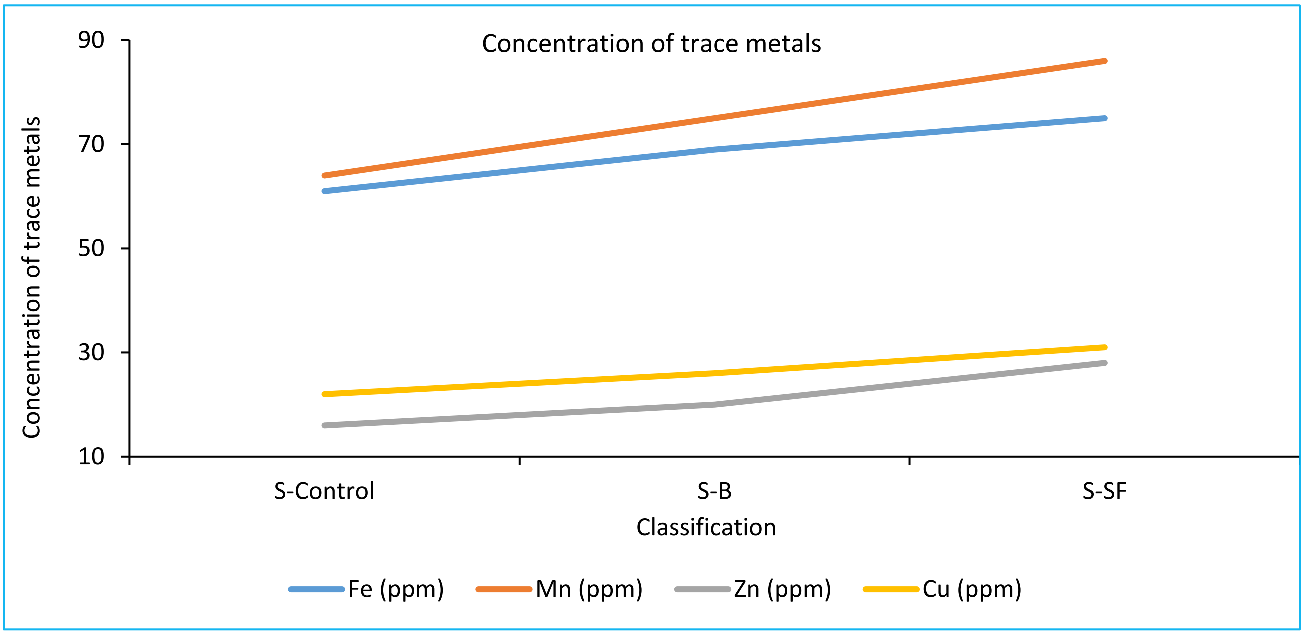
The value of manganese is minimum for S-Control i.e., 64 ppm and for S-B it was 75 ppm. Maximum value was observed in S-SF i.e., 86 ppm. S-Control had minimum value of zinc i.e., 16 ppm and for S-B it was 20 ppm. S-SF was found to have a maximum value of 28 ppm. Similarly, the value of copper increased gradually from S-Control to S-SF. S-Control had a minimum value of 22 ppm. For S-B it was 26 ppm and S-SF had a maximum value of 31 ppm (Table 2, Graph 2).

Table 2 Ash analysis of Surinam spinach

Classification	K^+ (%)	Ca^{2+} (%)	Mg^{2+} (%)	SO_4^{2-} (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
S-Control	2.36	0.49	0.91	0.16	61	64	16	22
S-B	2.98	0.68	1.2	0.25	69	75	20	26
S-SF	3.14	0.84	1.6	0.31	75	86	28	31



Graph-1



Graph-2

Table 3 Requirement of nutrients

Classification	Low value	Sufficient value	High value
K^+ (%)	2.0-2.49	2.50-3.50	>9.99
Ca^{2+} (%)	0.50-0.69	0.70-1.21	>5.0
Mg^{2+} (%)	0.40-0.99	1.0-1.60	>3.0
SO_4^{2-} (%)	0.1-0.19	0.20-1.0	>1.0
Fe (ppm)	50-59	60-201	>600
Mn (ppm)	20-29	30-251	>700
Zn (ppm)	20-24	25-61	>300
Cu (ppm)	3-4	5-26	>100

The U.S Department of Agriculture (USDA) National Nutrient Database for Standard References [7]

CONCLUSION

The present study was conducted to compare the progress of growth of Surinum spinach using bittern and solid fertilizer prepared using bittern. Ash analysis was done and the results were also compared. The study reveals that the growth rate of Suranium spinach was maximum when solid fertilizer was used. The method for the preparation of solid fertilizer is a cost effective and sustainable process. From the above study, it is concluded that bittern which cannot be transported easily can be converted to solid fertilizer and used effectively to promote sustainable agriculture and improve the economy.

LITERATURE CITED

1. Hocquet JC, Hocquet J. 1987. Food and Food ways. 1: 219.
2. Na CK, Park H, Jho EH. 2017. Utilization of waste bittern from saltern as a source for magnesium and an absorbent for carbon dioxide capture. *Environ. Sci. Pollution Res. Int*. 24(29): 22980-22989.
3. Ayoub GM, Merhebi F, Acral A, El-Fadel M, Koopman B. 2000. Seawater bittern for the treatment of alkalized industrial effluents. *Water Research* 34(2): 640-656.
4. Alamdari A, Rahimpour MR, Esfandiari N, Nourafkan E. 2008. Kinetics of magnesium hydroxide precipitation from sea bittern. *Chem. Eng. Process* 47: 215-221.
5. Marx H, Kaps S, Schultheis B, Pfänder M. 2019. Potassium sulfate – A precious by- product for solar salt works. *Bulletin of the Society of Sea Water Science, Japan* 73: 89-93.
6. Bhargava BS, Raghupathi HB. 1999. *Methods of Analysis of Soil, Plants, Waters and Fertilizers, Fertilizer Development and Consultation Organization*. New Delhi, 3rd Edition. pp 49-82.
7. Beaufils ER. 1973. Diagnosis and Recommendation Integrated System (DRIS), University, Natal Pietermaritzburg, South Africa. pp 132.