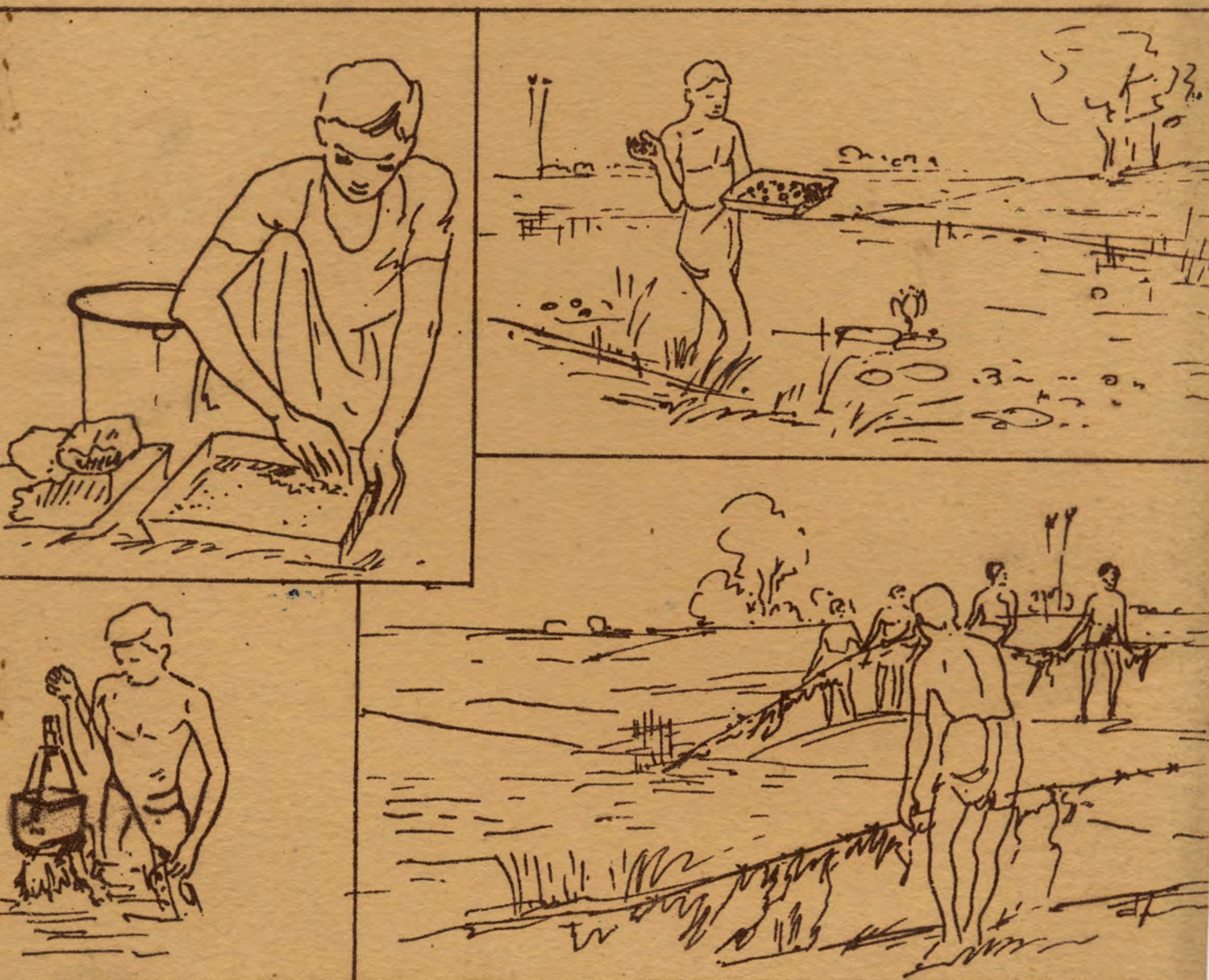
A REPORT ON COPPERSULPHATE TREATMENTS OF FISHERY PONDS FOR THE CONTROL OF WEEDS

1952 – 1970



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CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
BARRACKPORE : WEST BENGAL : INDIA.

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by

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FOREWORD

Investigations on the control of aquatic weeds with which the fishery waters are commonly infested, have been carried out at this Institute during the past several years. The use of copper sulphate, a common weedicide, used for the control of algal blooms and other types of weeds in varied types of waters all over the World, has been investigated for the control of a variety of rooted and floating weeds by Dr. (Miss.) E. Mitra, in collaboration with Shri S.M. Banerjee, Fishery Scientist (Retired) and Shri A.C. Banerjee, Senior Research Assistant of the Calcutta (Weed Control) Research Centre who are responsible for the chemical analyses only. In order to assess, adverse effects if any, as a result of use of copper sulphate in fishery waters, follow up studies (Section VIII of the Bulletin) to investigate the after effects of copper ion concentrations in the pond soil were continued for varying periods ranging from a couple of years to about ten years at different places. The results of these investigations have been embodied in the present bulletin. As has been brought out in these investigations, weed control in fishery waters can be fruitfully done with the application of copper sulphate mud pellets.

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(V. G. JHINGRAN)
DIRECTOR

INTRODUCTION

The ponds or any inland water areas if not properly managed, shall be infested with different types of vegetation commonly termed as 'weeds'. In whatever water areas the weeds might be present, there is an ever increasing demand to control them from the point of view of health, irrigation, etc. However from fish cultural point of view, weed control has its unquestionable importance. Weeds can be controlled by different means, namely manual, mechanical, biological and specially by the application of chemicals. The use of chemicals for controlling weeds gained some importance during the last decade of the nineteenth century and the early part of the twentieth. From fisheries standpoint the principles of weed control should be aimed at to control the growth of higher aquatic plants only, without affecting other fauna or flora present within the environment to be treated.

The Food and Agricultural Organisation of the United Nations while recommending the use of pesticides (1965) for agricultural purposes stated that:-

"All possible effects should be made to ensure that in the use of pesticides either for agricultural purpose or public health purposes there will be

(a) Minimum loss to aquatic life.

(b) Minimum degradation of the aquatic environment with consequest loss or reduction of aquatic stocks.

(c) Minimum danger to human beings.

Similarly in aquatic weed control the same principles should be accepted before any means are adopted for controlling the aquatic weeds. In fisheries the following are also to be protected :

(a) The fish and the fish food organisms.

(b) The fertility of the environment and

(c) The pond should not have any cumulative after effect".

Cocayne (1918) while working on agricultural weeds stated that control of weeds is a constant necessity in Newzealand. Of prime importance is the intensive study of the species causing damage, both from the autecological and the synecological aspects, knowledge of the habitats, relation to soil and climate, method of dissemination, power of variability and actual distribution is necessary before the work on weed control is taken up. In aquatic weed control similar studies on aquatic species are also very essential.

Blackburn (1966) stated that aquatic vegetation has a definite role in the development and maintenance of a balanced community. The proportion of plant area to water area, necessary for optimum fish production, has not been determined. Thus any attempt adopted for weed control should be limited to the "nuisance area" only without adversely affecting the other aspects of the aquatic environment. From fish cultural point of view, the weeds are to be controlled and not to be eliminated completely as an adequate amount of vegetation has a definite role to play in the productivity of fisheries waters and provide food and shelter to the fishes and other aquatic organisms.

Extensive work under controlled conditions as well as in the field, with commercial coppersulphate, has been carried out and the results are enumerated in this article.

Weeds commonly found in fishery waters

Some of the most common aquatic vegetation of the fishery waters which have been observed are listed below.

I. Botton rooted.

1. Hydrilla verticillata (Linn. f) Royle - Hydrocharitaceae.
2. Ottelia alismoides Pers. - "
3. Naias foveolata A. Br. - Naiadaceae.
4. Chara zeylanica willd. - Characeae.
5. Vallisneria spiralis Linn. - Hydrocharitaceae.
6. Limnophila heterophylla Benth - Scrophulariaceae.
7. Alternanthera sessilis Br. - Amarantaceae.
8. Potamogeton pectinatus Linn. - Naiadaceae.
9. Potamogeton crispus Linn. - "
10. Nechemandra Roxburghii Benth. - Hydrocharitaceae.
11. Monochoria hastaefolia Presl. - Pontederiaceae.

II. Marginal rooted.

12. *Colocasia antiquorum* Schoott. - Araceae.
13. *Cyperus articulatus* Linn. - Cyperaceae.
14. *Cyperus exaltatus* Retz. - "
15. *Cyperus corymbosus* Rottb. - "
16. *Scirpus articulatus* Linn. - "
17. *Panicum fluitans* Retz. - Gramineae
18. *Phragmites karka* Trin. - "
19. *Marsilea quadrifoliata* Linn. - Marsileaceae.
20. *Jussiaea repens* Linn. - Onagraceae.
21. *Ipomoea aquatica* Forsk. - Convolvulaceae.

III. Surface floating.

(a) With roots.

22. *Eichhornia crassipes* Solms. - Pontederiaceae.
23. *Pistia stratiotes* Linn. - Araceae.
24. *Spirodela polyrrhiza* Linn. - Lemnaceae.
25. *Lemna trisulca* Linn. - "
26. *Salvinia cucullata* Roxb. - Salviniaceae.
27. *Salvinia natans* Hoffm. - "
28. *Azolla pinnata* R. Br. - "

(b) Without roots.

29. *Wolffia arrhiza* Wimm. - Lemnaceae.

IV. Submerged floating

30. *Ceratophyllum demersum* Linn. - Ceratophyllaceae.
31. *Utricularia stellaris* Linn.f. - Lentibulariaceae.
32. *Utricularia flexuosa* Vahl. - "

V. Rooted emergent.

33. *Nymphoides cristatum* Griseb. - Gentiananceae.
34. *Nymphaea rubra* Roxb. - Nymphaeaceae.

35. <u>Nymphaea stellata</u> Wild - Nymphaeaceae

36. <u>Nymphaea lotus</u> Linn. - "

<u>Object of weed control</u>

In fishery waters these weeds are commonly found but all of them never occur together. Some of the weeds form an association in a definite ecological environment and with the changes occuring in the environment the association may also change its formation in respect of species or in numbers. The growth of the weeds depends on the ecological conditions of the environment in which they flourish but occasional qualitative and quantitative variations in the weed communities are observed with the changes in the outside environment. The weeds may have annual, biennial or perennial growth. Nursery ponds in which tender fish spawn are reared, the commonly present weeds are :- <u>Eichhornia</u> sp., <u>Pistia</u> sp., <u>Spirodela</u> sp., <u>Azolla</u> sp., <u>Hydrilla</u> sp., <u>Vallisneria</u> sp., <u>Nechemandra</u> sp., <u>Ottelia</u> sp., <u>Nymphoides</u> sp., <u>Potamogeton</u> spp., <u>Ceratophyllum</u> sp., <u>Naias</u> spp. and other such plants. The fish farmers every year, three to four months ahead of the spawning season, clean the nursery ponds by manual labour, fertilise them and keep them ready to liberate the fish spawn. This annual manual cleaning of nursery ponds, which is a must for the farmer for successful fish culture, causes him a recurring expenditure.

Likewise, in stocking ponds also manual clearing of weeds is there but that is once in two to three years only. In these ponds, in addition to the above plants, grasses and other marginal weeds also develop and grow healthily. When regular netting is done in the ponds, there is a check to some extent on the growth of these weeds but even then they are often found to be choking the entire pond. Ponds in which regular cleaning or regular fish cultural operations are not taken up, weeds grow and choke the water volume and surface completely. Even if some fish are there, it becomes very difficult for the owner to net them out as netting operations become difficult due to the presence of dense weeds. Besides, ponds which remain unattended for years and become derelict, the growth of vegetation in such water areas is so profuse that from a distance it looks like a field and not an expanse of water.

The higher aquatic plants multiply profusely by vegetative means. Seed formation is there but the environment for seed germination and growth of the new plant may not be always suitable. Therefore, the increase in numbers by the formation of new plants from seeds can be ignored. These plants are very adaptive and they are capable of forming vegetative buds or any vegetative part getting detached from the parent plant can pass off to a stage of dormancy whenever they face an adverse condition. These dormant vegetative buds or parts generally remain buried within the upper layer of the bottom soil. Many a times due to sudden changes in the environment the plants present in the water die out to a great extent, but the vegetative units, which are buried within the soil remain intact and when suitable environmental conditions reappear they give rise to new plants. The surface floating plants also under adverse environmental conditions, pass into dormant stage by forming different types of vegetative buds which remain buried in the bottom soil.

From these observations it becomes evident that growth and overgrowth of weeds minimise the water area for fish culture and also increase the expenditure of fish farmers for fish cultural operations. Hence the control of weeds is an essential factor for all types of water expanses and specially in waters for fish culture. If the weeds, in fishery ponds, can be controlled successfully then the available water areas will increase in volume for fish culture enbling the fish farmers to go ahead with greater incentive for fish culture operations which will provide him with increased returns in terms of fish production.

COMMON METHODS OF WEED CONTROL

The science of weed control has advanced rapidly during the last 25 years. Old and so-called reliable methods of control have blended with the very modern chemical techniques. From long past, farmers know it well that proper construction of ponds play an important part in controlling pond weeds. The pond margin should not be shallow for a larger area. Many rooted aquatic plants do not easily establish themselves in deeper areas, for example, grasses start their growth on the shallow margins upto 1/2 to 1 metre depth. When the margin is thus covered with grass it becomes very difficult to lower the net in water for fishing.

Drying is a simple way to control many submerged aquatic weeds. Even if the water is drained out from a pond then several days exposure of the bottom soil to strong sun can kill the weeds but again when water is there in the pond for a few months, regrowth of vegetation will be observed. So this method can keep the pond weed free for a few months only. In lightly infested areas cleaning by manual labour may be the most practical method of weed control. If a new infestation is cleaned by manual labour then it is possible to prevent the weed from spreading. In deeper waters where hand pulling is not practicable, chaining or barbed wire pulling through the bottom soil is being done to prevent the overgrowth of submerged weeds.

Many chemicals have been tried and they can effectively control many aquatic weeds. Widely used chemicals for aquatic weed control are 2,4-Dichloro-phenoxy acetic acid, coppersulphate, sodiumarsenite, 2,4,5 - trichlorophenoxy acetic acid, many other ICI manufactured chemicals. Agroxone and some new chemicals like Dalapon, Amitol, Simazine, Grammoxone, Terbacil weed killers, Ammnotriazole, etc. are also being tried.

In the tropical countries it is very laborious to check the growth of the vegetation. Before any weed control measures are adopted it is necessary to carry out basic ecological studies on plants and animals in a particular aquatic environment where such attempts are to be made. Also it must be considered who will be most interested to utilise the method of control that is formulated, because it will be difficult for common man to apply the scientific methods. So the method adopted is to be devised in such a manner that it can be operated by every individual. Based on all these factors, the method of weed control should be found out which will be cheap, easy for handling and can be used by any individual in any given water area.

Several methods of weed control were tried (Mitra 1959). Commercial coppersulphate which is easily available in the country and is not expensive, was also put to trial for weed control in fish ponds. To start with, the chemical was applied in the volume of water. The dosage of coppersulphate required to control the different types of vegetation, was in many cases adversely affecting the fish, plankton and other lives present in the treated environment. Steward and Nelson (1972) have stated that "The conventional method of aapplying liquid formulations of herbicides for the control of submersed aquatic weeds is to apply a phyto-toxic concentration of herbicide in the entire volume of water. Injury to nontarget organisms - both plant and animal - caused by this type of treatment can be quite severe, depdnding upon the toxicity of the herbicide. This injury may be reduced, however, applying herbicides in inert carries to give controlled release, rather than treating the entire volume of water. It may be possible with selected carriers to release the herbicide near the soil-water interface where the plant growth originates and where the propagating structures are located. Proper timing of application may prevent dense growth of aquatic plants by inhibiting or preventing growth early in the growing season. Controlled release of a herbicide from a carrier may also prevent growth which emerges from propagating structures buried in the bottom mud".

Autecological studies of the higher aquatic plants by the author (1955a,1955b, 1960, 1964, 1966, 1972 in press) have shown that for controlling growth and regrowth of macrovegetation, the bottom soil of ponds should be treated first. This will destory the underground vegetative parts, different types of vegetative and reproductive buds and ultimately check the regrowth of plants entirely. Therefore, the bottom soil treatment with coppersulphate in "mud pellets" was initiated by the author at this Institute in 1963 much before Steward and Nelson's suggestion of releasing the herbicide in inert carriers near the soil-water interphase in 1972 came to light.

COPPERSULPHATE TREATMENTS

The investigations on weed control with the application of coppersulphate were initiated in 1952 at Cuttack Sub-station of the Institute. At the commencement, laboratory experiments were conducted in cement cisterns with soil, water and plants by applying copper sulphate in solution to the volume of water. It is a wellknown fact that coppersulphate precipitates in alkaline water, hence the chemical was applied after lowering the pH of water with commercial sulphuric acid. The plant grown in cisterns was Hydrilla verticillata (Linn. f) Royle. The experiment conducted was as under :-

		After 28 days.	After 54 days.
A. I. Cisterns$_1$	= Control	- Plants healthy	- Plants healthy
" 2	= pH of water reduced to 6.0 + 2 ppm of coppersulphate solution.	- Plants healthy	- Plants healthy
" 3	= pH of water reduced to 6.0 + 6 ppm of coppersulphate solution.	- Plants healthy	- Plants healthy
" 4	= pH of water reduced to 6.0 + 10 ppm of coppersulphate solution.	- All plants completely decomposed, water turned brownish.	- Plants nil. No. odour, water slightly greenish, more phytoplankton present.
" 5	= pH of water reduced to 5.0 and pH maintained between 5.0 and 6.0.	- Plants healthy and green.	- Plants healthy and green.

Repeating the above experiment the 10 ppm dose at a reduced pH of 6.0 was established.

Appendix I, Experiment No. 1

II. In the second series of cistern experiment the addition of the optimal dose was tried in different ways :-

Cistern 1 = Control.

" 2 = 10 ppm coppersulphate solution added to the water, pH not being reduced.

" 3 = pH of water reduced to 6.0 + 10 ppm coppersulphate solution added.

" 4 = pH of water reduced to 6.0 + 2 ppm coppersulphate solution added to the water for 5 alternate days.

" 5 = pH of water reduced to 6.0 + 1 ppm coppersulphate solution added to the water for 10 consecutive days.

Complete death and decomposition of plants was observed in 10 ppm of coppersulphate solution when added in water in one instalment after reducing the pH of water to 6.0.

Appendix I, Experiment No. 2

III. To find out the optimal level of pH at which no copper ions will be removed by inorganic precipitation, the pH range was tried between 6.0 to 11.0. In ponds with overabundant growth of vegetation it is very difficult to lower the pH and to retain the pH at the lower level for a few hours so below 6.0 the lower ranges of pH were not tried. Coppersulphate concentration of 10 ppm was applied in all the experimental ranges of pH tried. Best result was obtained in pH 6.0 in which there was almost no precipitation.

IV. Further laboratory experiments were conducted with the plant <u>Ottelia alismoides</u> L. in the following manner :-

Cisterm 1 = Control.

" 2 = pH of water lowered to 6.0 + 2.0 ppm of coppersulphate solution added to the water.

" 3 = pH of water lowered to 6.0 + 4.0 ppm of coppersulphate solution added to the water.

" 4 = pH of water lowered to 6.0 + 6.0 ppm of coppersulphate solution added to the water.

" 5 = pH of water lowered to 6.0 + 8.0 ppm of coppersulphate solution added to the water.

Cistern 6 = pH of water lowered to 6.0 + 10.0 ppm of coppersulphate solution added to the water.

Ottelia plants died and decayed completely in 60 days in cistern No. 6 in which 10 ppm of coppersulphate solution was added after lowering the pH of water to 6.0.

Appendix No. I, Experiment No. 3.

The above experiments led to the establishment of 10 ppm concentration of coppersulphate solution alone to be applied in water volume at a reduced pH of 6.0 to control different types of higher aquatic plants.

V. Field trials of the above experiment were conducted in the ponds at Killa Fish Farm, Cuttack.

It was observed that when coppersulphate was added at a concentration of 10 ppm after lowering the pH to 6.0, the reaction is quick and complete. Visible signs of withering of the plants Ottelia alismoides, Nymphoides cristatum and Naias faveolata started within 3-4 days and all the vegetation decayed and settled at the bottom within a duration of 25 days.

The results of the above field trials have been brought out in a scientific paper (Banerjea, S.M. and Eva Mitra 1954).

VI. Further field experiments were conducted at Calcutta, West Bengal in the two National Library ponds infested in abundance with Hydrilla verticillata and Chara zeylanica. On the 30th day from the first treatment, 95% of the total vegetation decayed giving blackish colour and pungent smell to the water. The results of the experiment have been brought out in a scientific paper (Eva Mitra, 1959). One great disadvantage of this treatment was that after the application of 3 intermittent doses the copper ion concentration in water came up for a few hours between 8.2 and 8.8 ppm from nil or trace. This concentration is harmful for all living organisms within the treated environment. Therefore a new line of approach in the use of coppersulphate mixed with mud as "pellets" was taken up in 1963 at the Cuttack Sub-station of the Institute. The quantities of copper sulphate required for different doses were calculated separately and then converted into kg. per hectare for treating the bottom soil of ponds.

Various doses tried in 10 litre glass jars were :-

10 ppm	=	17.5 Kg/ha
15 ppm	=	26.25 Kg/ha
20 ppm	=	35.0 Kg/ha
25 ppm	=	43.75 Kg/ha
30 ppm	=	52.5 Kg/ha
35 ppm	=	61.25 Kg/ha
40 ppm	=	70 Kg/ha
80 ppm	=	140 Kg/ha
100 ppm	=	175 Kg/ha
120 ppm	=	210 Kg/ha

VII. Under laboratory experiments these doses were effective in killing Hydilla veeticillata and Vallisneria spiralis plants. The experiment was repeated several times. As a result of these experiments doses @ 35 and 45 Kg/ha were considered suitable for application in natural pond soils. Each dose is to be applied more than once, in intermittent manner, to effect complete destruction of the plants present in the treated environment. The percentage of death of plants caused by each dose applied only once is given below :-

Experimental plants.	10 ppm 17.5 Kg/ha	15 ppm 26.25 Kg/ha	20 ppm 35 Kg/ha	25 ppm 43.75 Kg/ha	30 ppm 52.5 Kg/ha
Hydrilla Verticillata	50%	60% dead	80%	85%	90%

Experimental plants.	35 ppm 61.25 Kg/ha	40 ppm 70 Kg/ha	80 ppm 140 Kg/ha	100 ppm 175 Kg/ha	120 ppm 210 Kg/ha
Hydrilla Verticillata	90%	95% dead	95%	100%	100%

From 17.5 upto 210 Kg/ha plants showed death but the time taken for complete destruction varied. Basing on all the points the rate of doses selected for field trials were 35 and 45 Kg/ha, but in every trial 2 to 5 doses were applied, as required , in intermittent manner.

VIII. Another set of laboratory experiment was conducted to ascertain whether coppersulphate when used in powder form in mud pellets is more effective than when used in crystal forms. It was observed that copper ion concentration in the volume of water in experimental jars was more when coppersulphate crystals were used and also propoetionately the increase in copper concentration in soil was much less. But when coppersulphate and pellets were used there was an increase of copper ion concentration only at the soil-water interphase and copper concentration in soil increased much more than when copper crystals were used. With mud pellet treatment the Hydrilla plants died and decomposed completely within 15-20 days. The underground parts of Vallisneria plants completely decayed and floated after 15-20 days when they could be removed from the jars. Regrowth of the plants was nil.

Appendix II, Experiment No. 6.

PREPARATION AND APPLICATION OF COPPERSULPHATE IN MUD PELLET FORM

Soil from the adjoining area of the pond, required to be treated is collected and cleared of all pebbles, stones, grasses and other such vegetation present in it. The cleared soil is then properly powdered. Depending upon the intensity of weed infestation the amount of coppersulphate required for treating the area is calculated on the basis of the recommended dose of 35 to 45 Kg/ha. The chemical is powdered and thoroughly mixed with mud in the ratio of 1: 100 (1 part chemical : 100 parts dry soil). By adding small quantities of water a thick paste is made. From this paste mud pellets (15-20 mm. in diametre) are prepared and they are then carefully thrown in the pond water so as to attain an even distribution on the pond bottom. If a larger water area is required to be treated, the pellets are thrown from a boat ensuring an even distribution.

A number of field trials both at the Killa fish farm, Cuttack and in various places in West Bengal (Viz., Cuttack = Nursery Pond No. 25, Rearing pond No. 17, a part of Kanika Raj Bati Pond, a part of Killa moat. West Bengal = Bantala Salt Lake area 2 ponds, Ramrajatolla, Howrah District 2 ponds, Botanical Garden Sibpore 3 ponds) were conducted with a view to control submerged weeds in the fish ponds using copper sulphate in mud pellet form. The results of these experiments with details of weed infestations, doses of coppersulphate, number of intermittent applications and the results obtained are presented in appendix II, Experiments No. 7-20. The results of these experiments have been reported by the author in various scientific communications (E. Mitra and A.C.Banerjee 1970, 1971, 1972).

RESULTS

1. Chemical aspects of water and soil

When coppersulphate is applied to the bottom soil in mud pellets the increase in copper ion concentration in water and soil phase is proportinate to the increase in dosages. With a treatment @ 180 Kg/ha of coppersulphate in 4 intermittent doses in a pond, a maximum increase of copper ion in water, is after 4 hours of the first treatment was .02 ppm in surface layer and .03 ppm in interphase layer of water. But in soil the maximum increase is 3 mg/100 gms of soil of water soluble copper and 14 mg/100 gms of soil of acid soluble copper in four days after the second dose.

In a few experiments when the pond soil treated @ 140, 105 and 90 Kg/ha the copper concentration in soil rose to maximum from 4th to 16th day after the application of the last split dose. But when the pond woil treated @ 180, 175, 95.8 and 75 Kg/ha, the copper concentration in soil rose to maximum before the application of the last split dose.

Whether the entire area or a part of a given area is treated, the increase in the copper ion concentration in surface as well as interphase layers of water showed variation depending upon the depth of the treated area. At a maximum depth, 5 to 6.5 metre, (Appendix III, Pond No's 3 and 8) the difference in copper ion concentration between the surface and interphase water layers was 0.2 ppm. The least depths treated were 1 to 4 metres and the difference in copper ion concentration between the two layers of water varied from 0.01 to 0.08 ppm. However, in one case (Appendix III, experiment No. 5) though the depth varied from 3.5 to 5.5 metres the copper ion concentration in both the layers of water was observed to be the same.

2. Effect on bottom biota

Generally in water areas choked with higher aquatic plants, shells of dead molluscs are only encountered though in few numbers. Two to three months after the bottom soil treatments of ponds with coppersulphate and removal of the dead vegetation, gradually chironomid larvae, mollusca and oligochaetes make their apperance.

3. Affectations of plants

All the rooted plants remain on the bottom soil in a large or in a small area. All other plants rooted or not rooted, pass their reproductive stages in a dormant state either buried in the bottom soil or resting on the bottom soil. When the bottom soil is treated with coppersulphate the underground parts of the rooted plants such as roots, tubers, rhizomes, runners etc. absorb first the chemical from soil and pass it on to the other parts of the plants. The maximum absorption being in the roots, the plants with decaying underground parts float up before other parts of the plants are affected. These half decayed floating plants are then removed from the pond by manual labour. Lemna spp., Spirodela spp., Pistia sp., Eichhornia sp., Ceratophyllum sp. and other floating plants are not affected directly as is the case with rooted plants, but their vegetative and reproductive parts, which by natural breakage from the parent plants go down in the volume of the water and settle on the bottom mud, are adversely affected. If the surface, bottom and the entire volume of water is thus made free of vegetation by manual labour, then, the remaining underground parts shall absorb the copper ion present in the coil and get decomposed, In this manner compl te regrowth of the vegetation within a treated environment is checked.

4. After effects of coppersulphate treatments

When coppersulphate is applied to the bottom soil, which is generally alkaline in nature, the copper is released to some extent in the adjoining water and the rest remains in the soil in an insoluble form. If the soil of the treated pond by any chance becomes acidic in nature, for example, by the release of factory effluents or any sewage washings entering the pond, then it is likely that the insoluble copper within the soil may change into soluble form and get mixed in the pond water or may remain within the soil rendering it sterile.

To verify the truth of this fact a laboratory experiment was conducted on the release of copper ions from treated soil and it was observed that if the bound up copper is released from the soil in the soil-water interphase it does not have any harmful effect on the fish or fish food organisms present in the pond. Also in whatever insoluble form the copper may remain within the bottom soil, it does not make it strile. (Mitra and Banerjee, 1968).

Based on this fact further laboratory experiment was conducted to find out the fate of copper which is applied to the bottom soil in the form of coppersulphate in mud pellets. Six glass jars (each of 10 litre capacity) were filled with a 80 mm. thick layer of soil and 2 litres of tap water in each. Water and soil characteristics as to pH and copper ion concentration were noted prior to the treatment of each jar with coppersulphate mud pellets @ 105 Kg/ha, applied in three intermittent doses of 35 Kg/ha within a period of 7 days. The observation continued till the copper ion in water reached the normal concentration. Twelve days after this, that is, 52nd day from the third dose, the soil in 3 layers were taken out and analysed.

From the data given below it is observed that after the treatment of the bottom soil with coppersulphate, maximum rise in copper ion concentration in water was 0.18 ppm which came down to normal (0.01 ppm) on the 39th day from the day of application of the last intermittent dose. Twelve days later when there was no change in the copper ion concentration in water, 10 ml of concentrated sulphuric acid was added to the soil in each jar. One hour after treatment pH of the water came down to between 4.4 and 4.6 and the copper ions in water increased to 0.2 and 0.22 ppm

(Table cited below). The maximum increase of copper ions in water (0.8-0.85 ppm) was observed on the thirtyeighth day after which it started decreasing and reached the normal value (0.01 ppm) on the one hundred and fortyfirst day. When the copper ions in water remained at 0.01 ppm for 12 days, then the water and soil samples of the jars were taken out for analyses.

5. Absorption of copper ion in the fish flesh when fish are present in the treated environment .

In the laboratory, in an aquarium (L=90 cm, W=40 cm, Depth of water 28 cm.) provided with healthy *Hydrilla* and *Vallisneria* plants. 300 specimens of *Labeo rohita*, *Catla catla*, *Cirrhins mrigala* and *Labeo bata* (av. size 35-40 mm) were introduced. Each species of fish were 75 in number. After 10 days of introduction specimens of each species were taken out are dried to serve as control samples. Before treatment the copper ion concentration in water was 0.01 ppm. The soil (8 cm in thickness) of the aquarium was treated with coppersulphate in mud pellets at a dose of 105 Kg/ha within the period of 7 days. The total dose was applied in 3 intermittent doses each @ 35 Kg/ha. On the fifth day, after the treatment, copper ion concentration rose to a maximum of 0.18 ppm, when 25 specimens of each species were taken out of the treated water for analysis. Hundred fish were thus removed leaving another hundred in the aquarium which later survived healthily. The fish flesh of all the species from the individual samples removed was separately analysed for the presence of copper. The results obtained are presented below :-

Analysis of fish flesh for the presence of copper

Before treatment	Fish taken out 5 days after treatment
Per 100 gms. of dried fish flesh	
1. *Labeo rohita* = 1 mg of copper	4 mg of copper.
2. *Cirrhins mrigala* = 1 mg of copper	4 mg of copper.
3. *Catla catla* = 1 mg of copper	3 mg of copper.
4. *Labeo bata* = 1 mg of copper	3 mg of copper.

The experiments being repeated thrice led to the conclusion that the fish when present in the treated environment absorb the copper ions from the water. But after the absorption the concentration of copper ions present in the fish flesh is neither harmful for the fish nor for human beings who consume the fish as from all the treated ponds, whether Government of Private, the fishes were taken out and sold to public and there was no complaint of any poisoning or so.

The details of analyses presented below :-

	Water pH	Water Copper ion ppm Surface layer	Water Copper ion ppm interphase layer		Soil pH	Soil Copper/mg/100 gms of soil Water soluble	Soil Copper/mg/100 gms of soil Acid soluble
Before treatment	8.4	.01	.01		7.0	0.1	0.2
In 7 days, 3 doses of coppersulphate anplied in mud pellets, each dose @ 35 Kg/ha, total being 105 Kg/ha.							
4th day from the third dose	7.3	.15	.18				
14th " " " " "	8.4	.10	.10				
23rd " " " " "	8.4	.05	.06				
39th " " " " "	8.4	.01	.01				
52nd " " " " " 10ml concentrated sulphuric acid applied to the soil of earh jar with a pipette, to study the release of copper from soil.							
1 hour after treatment with acid	4.4-4.6	.2	.22				
5 " " " " "	4.4-4.6	.2	.22				
2nd day " " " "	4.4-4.6	.2	.2				
4th " " " " "	4.4-4.6	.15	.16		5.0	0.5	2.0
17th " " " " "	4.4-4.4	.2	.21				
38th " " " " "	4.4-4.6	.8	.85				
45th " " " " "	4.4-4.6	.6	.65				
59th " " " " "	4.4-4.6	.4	.45		5.6	.08	.4
75th " " " " "	4.4-4.6	.2	.22				
92nd " " " " "	4.6-4.8	.04	.05				
112th " " " " "	6.8-6.8	.02	.02				
141st " " " " "	6.8-6.8	.01	.01	First layer	6.0	.05	.4
				Second layer	6.2	.1	.6
				Third layer	6.2	.1	.6

FOLLOW UP OBSERVATIONS ON THE AFTER EFFECTS OF COPPERSULPHATE IN THE TREATED POND ENVIRONMENT

After the weeds are eradicated by the treatment of the bottom soil with coppersulphate mud pellets, follow up observations of the treated ponds were continued to find out whether coppersulphate remaining within the bottom mud in some form or the other, affects the pond environment in later years adversely or not. Generally observations were continued for four to five years but in a few cases wherever it was possible observations for a period of ten years were also continued, The details of observations are summarised in the table 'A'.

From the above observations it can be concluded that the copper ion concentration in water at the soil-water interphase as well as in the bottom soil, just after the treatment shows some increase but later the copper ion concentrations become normal. Follow up observations showed that there was no where sudden release of copper ion from the treated soil and also the bottom treatments did not show any adverse affectations neither on the environment nor on the lives present in the environment. It has been observed that after the treatment when the ponds are cleared of the decayed weeds, the growth of fish food organisms, the bottom biota proceeds in the normal way and the ultimate fish production is improved. In a few treated ponds later observations carried out on the fishes and it was observed that copper sulphate treatment did not adversely affect the gonadial maturity of the fishes.

DOSES OF COPPER SULPHATE RECOMMENDED FOR APPLICATION AS MUD PELLETS

Copper sulphate treatment in solution in the volume of water increases the copper ion concentration in water from trace or 0.01 ppm to 0.2 to 6.0 ppm. The fish population and all other lives present within the treated environment get destroyed above 1.5 ppm concentration of copper ion in water. For cleaning up derelict areas, where fish population is of no consideration, the water can be treated with four intermittent doses of copper sulphate solution each dose @ 10 ppm. Every time when the solution is made, a little sulphuric acid to be added in the solution to avoid precipitation of copper. By this treatment along with the vegetation all other unwanted insects and animals present in the pond environment can be destroyed completely and removed.

TABLE - A

Results of the follow up observations.

Sl. No.	Name of the pond.	Period of treatment and the nature of dose applied.	Maximum rise of copper ion in water at the soil-water interphase.	Condition of soil before the treatment.	Period after the treatment.
1.	N.P. 25, Cuttack, Orissa.	23.9.64 - 5.10.64 4 intermittent doses applied each @ 45 Kg/ha, total 180 Kg/ha.	0.02 ppm 10 years after 0.01 ppm.	pH 7.0 Water soluble copper 0.1 mg. Acid soluble copper 0.2 mg.	10 years after. 6.4 0.1 mg/100 gms of soil. 0.2 mg/100 gms of soil.
2.	R.P. 17, Cuttack, Orissa.	26.11.64 - 2.12.64 5 intermittent doses applied each @ 35 Kg/ha, total 175 Kg/ha.	0.5 ppm 10 years after 0.01 ppm	pH 7.0 Water soluble copper 0.1 mg. Acid soluble copper 0.2 mg.	6.8 0.1 mg/100 gms of soil. 0.2 mg/100 gms of soil.
3.	Chakrabaithak pond, Calcutta, West Bengal	3.12.68 - 12.12.68 4 intermittent doses applied each @ 35 Kg/ha total 140 Kg/ha.	0.45 ppm 5 years after 0.01 ppm	pH 7.2 Water soluble copper 0.1 mg. Acid soluble copper 0.2 mg.	5 years after 6.8 0.1 mg/100 gms of soil. 0.2 mg/100 gms of soil.
4.	Gamla pond, Botanical Garden Sibpore, West Bengal	18.4.69 - 29.4.69 4 intermittent doses applied each @ 35 Kg/ha total 140 Kg/ha.	.65 ppm 5 years after 0.01 ppm	pH 7.0 Water soluble copper trace Acid soluble copper 0.2 mg.	6.6 trace 0.2 mg/100 gms of soil.
5.	King Lake 1, Botanical Garden, Sibpore, West Bengal	20.11.69 - 17.12.69 4 intermittent doses applied each @35,10,15,15 Kg/ha total 75 Kg/ha.	.14 ppm 4½ years after 0.01 ppm	pH 7.2 Water soluble copper 0.1 mg. Acid soluble copper 0.2 mg	4½ years after. 7.2 0.1 mg/100 gms of soil. 0.2 mg/100 gms of soil.
6.	Kind Lake 2, Botanical Garden, Sibpore West Bengal.	21.3.70 - 28.3.70 3 intermittent doses applied each @35,20,20 Kg/ha total 75 Kg/ha.	.08 ppm 4 years after 0.01 ppm	pH 7.2 Water soluble copper 0.1 mg. Acid soluble copper 0.2 mg.	4 years after. 6.4 0.1 mg/100 gms of soil. 0.2 mg/100 gms of soil.

Doses recommended for the application of copper sulphate in mud pellets to the pond bottom in water areas where fish life is present are to be as follows :-

(a) For eradication of annual vegetation :- 3 intermittent doses are to be applied within 10 days, each dose @ 35 Kg/ha, total being 105 Kg/ha.

(b) For eradication of perennial vegetation :- 4 intermittent doses are to be applied, the first three being applied within ten days and the last dose ten days after the application of the third dose. Each dose being 35 Kg/ha, thus the total dose applied being 140 Kg/ha.

(c) For eradication of grasses and other strong standing plants :- 5 intermittent doses are to be applied, the first 3 being applied within ten days, the fourth ten days after the third dose and the fifth one in between 10 and 15 days after the application of the fourth dose. Each dose being @ 35 Kg/ha, total dosage applied being 175 Kg/ha.

Thorough success depends on the application of the chemical together with the manual cleaning of the treated vegetation, however, the size and depth of each pond and also the type of vegetation present to be taken into qccount very carefully.

COST OF TREATMENT

I. 1. Three dosages @ 35 Kg/ha = 105 Kg of copper sulphate
cost of 105 Kg of copper sulphate @ Rs. 450/ quintol
= Rs. 472.50 p.

2. Labour charges.
8 persons for each application
(a) that is 8 x 3 doses = 24 persons.
(b) manual clearance = 12 persons/ha area
= 24 + 12 = 36 persons in total.
Labour charges to be paid @ Rs. 5/labour
= Rs. 5 x 36 labourers = Rs. 180/-

Total expenditure = Rs. 472.50 p. + Rs. 180.00
= Rs. 653/-

II. 1. Four doses @ 35 Kg/ha = 140 Kg of copper sulphate
(a) Cost of 140 Kg copper sulphate @ Rs. 450/quintol
= Rs. 630/-

(b) i) Hands applied for application.
8 persons/dose x 4 doses = 32 persons.
Labour charges to be paid @ Rs. 5/labour
= 32 x 5 = Rs. 160/-

ii) Hands applied for manual clearance.
12 persons x 2 days = 24 persons
@ Rs. 5/labour = 24 x 5 = Rs. 120/-

Total expdnditure = Rs. 630.00 + Rs.160.00 + Rs. 120.00
= Rs. 910.00

III.1. 5 doses @ 35 Kg/ha = 175 Kg of copper sulphate.
(a) Cost of 175 Kg copper sulphate @ Rs. 450/quintol
= Rs. 787.50 p.

(b) (i) Hands applied for application :
8 persons/dose x 5 doses = 40 persons
Rs. 5/labour x 40 persons = Rs. 200/-

(ii) Hands applied for manual clearance:
12 persons/day x 5 days = 60 persons
Rs. 5/labour x 60 persons = 300/-

Total expenditure = Rs. 788.00 + Rs. 200.00 + Rs. 300.00
= Rs. 1,288.00

It may be mentioned that the fish farmers who own the ponds, shall buy only the chemical and the fishermen who work for the farmer shall work in place of labourers. In this way the cost of labourers can be saved by the fish farmers.

In case of private individuals having a pond or two for culturing fish the expdnditure for the labourers can be reduced if the fishermen who do the netting operations attend to the manual removal of the dead weeds.

EFFECT OF PRESERVATION OF
COPPER SULPHATE MUD PELLETS

For the above laboratory and field experiments freshly prepared copper sulphate mud pellets were tried. Experiments were conducted to study the effect of preservation or storage on these mud pellets before they were put to use.

Fifteen sets of mud pellets were prepared. For each set one dose @ 35 Kg/ha were taken. Out of the fifteen sets three were applied immediately after preparation in three jars. The other twelve sets were air dried and stored and applied at definite intervals. In each set the retult given on the average of 3 jars :

Copper ion in water

Application made	1st set just after preparation	2nd set 7 days after.	3rd set 14 days after.	4th set 30 days after.	5th set 60 days after.	Control No applicatin
Before treatment	.01 ppm	.01 ppm	.01 ppm	.01 ppm	.01 ppm	.01 ppm
12 hours after treatment	.13	.12	.11	.14	.09	.01
24 " "	.19	.18	.16	.17	.11	.01
2nd day "	.21	.19	.18	.17	.15	.01
3rd " "	.18	.17	.16	.15	.16	.01
4th " "	.17	.15	.12	.13	.15	.01
5th " "	.11	.13	.1	.1	.13	.01
6th " "	.07	.11	.08	.1	.13	.01
7th " "	.05	.09	.06	.09	.09	.01
8th " "	.05	.07	.04	.07	.07	.01
9th " "	.02	.05	.02	.05	.05	.01
10th "	.02	.02	.01	.03	.03	.01
15th "	.01	.01	.01	.01	.01	.01
21st "	.01	.01	.01	.01	.01	.01
28th "	.01	.01	.01	.01	.01	.01

On the basis of the above experiments it has been concluded that the freshly prepared mud pellets are best for use. But the effectiveness of these on storage is maintained for a period of 30 days during which the dried, stored pellets can be utilised effectively.

ADVANTAGES OF BOTTOM SOIL TREATMENT WITH COPPER SULPHATE MUD PELLETS

The advantages of using coppersulphate in the mud pellet form for controlling aquatic weeds can be briefly summarised below :-

1. When a large water area is choked with aquatic vegetation then without putting up any barrier or bundh, incurring extra expenditure, the bottom soil of the entire area can be treated in parts.

2. The chemical in high concentration is poisonous but when applied to the soil in low doses as mentioned in the text, neither the fish nor the fish food organisms are affected adversely. The chemical when applied in mud pellets to the bottom soil the copper ion in the soil-water interphase rise within 110 cm. depth from the bottom soil. The highest concentration available was 0.68 ppm but this concentration is much below the permissible limit of 1.0 ppm recommended for drinking water by the World Health Organisation. During the period of treatment even, the water of the pond can be used by human beings, cattle and all lives.

3. The treatment neither has any cumulative after effect on the soil nor it makes the soil sterile. Moreover the decay of the underground vegetative parts within the soil, increases the fertility of the soil.

4. In controlling the weeds by this treatment, the recurring expenditure of the fish farmers can be completely checked in due course.

5. The chemical, not being very expensive, is easily available in the market.

DISCUSSION

Scientists like Sommer (1931) and also Lipman and Mackinney (1931) have shown that copper is essential for the growth of some plants. The latter authors examined the growth of barley in water cultures with and without a small supply of copper and found that vegetative growth of the plants was less in complete absence of copper, while normal seed production was also completely inhibited. The chemical is easily available within the country and the cost is within the reach of small fish farmers who are engaged in fish farming. If the farmer is sure of successful use of the chemical as a weedicide and if the chemical is not adversely affecting the fish life or the fish food organisms present in the ecosystem then the farmer will be ready to accept the use of the chemical. Farmers sometimes have in possession big areas which cannot be kept clean by annual manual clearance and also for them the manual clearance becomes too expensive. Some derelict areas which are beyond their means to be cleaned by manual labour or by common mechanical means, the farmers are ready to accept the use of a chemical for weed clearance of such areas.

The treatment with copper sulphate mud pellets satisfies the common farmers. The author worked in the ponds of fishery enterpreneurs in Salt Lake Sewage fed fishery, in the ponds of common fish farmers at Ramrajatolla and all were found to be satisfied with the efficacy of the treatment. It has also been observed that when the weeds are once cleared, the pond owner should keep a close watch on the regrowth of the vegetation. Generally it has been observed that after treatment when the weeds are 60-80% affected they are cleaned by manual labour, then, after the clearance of weeds the ponds remain completely weed free for a few months. There are occassional regrowths of stray plants which can be easily controlled manually. If, in this manner, the pond owner keeps a watch for a year after weed control, while the fish cultural operations are carried out in the pond, the pond will never have any weed infestations. But if the pond is kept fallow, without any fish culture, then automatically nature will play its own role and healthy weeds will appear.

Hence immediately after weed control the ponds should be utilised for regular fish cultural operations and also the water should be allowed for use by the neighbouring inhabitants as that will help in the play of fish as well as growth of fish food organisms.

The uprooted plants remain floating with decayed underground parts. If manual labour is not applied for their removal then these plants shall gradually adapt themselves in the environment, and instead of dying, they will survive till they again touch the marginal soil or a similar non-treated area where they will start a new life. Hence manual clearance is an essential factor in bottom soil treatment methods. By this method of treatment 75-80% of the existing plants are affected and when they are removed by manual labour their growth and also the growth of other new plants are completely checked.

When in a half decayed state the vegetation is present in a pond, there is chance of oxygen depletion in the water which shall lead to fish mortality. To avoid all hazards of the fish and the fish food organisms, after careful application of the ehcmical, a watch must be kept on the affected vegetation, which must be removed within a reasonable time keeping in view the cost of labour involved and also the healthy pond environment for fish life.

The success lies in the method of application and clearance by manual labour. The application should be done in such a manner that the plants get the opportunity of absorbing the maximum amoubt of the chemical available in the mud pellets.

When the bottom soil is being treated with the chemical there is a rise in the copper concentration in the soil-water interphase layer. This increase is generally observed in water at the end of the application. In soil the maximum increase in copper concentration is observed in some cases after the last dose and in some other cases much before. If there is rain during and after treatments then in water the increase in copper ion is disturbed and further rise is not observed, but the rain does not hamper the adverse affectation of underground parts of plants by the chemical. The soil absorbs copper ions from the applied copper sulphate and from the soil the copper is absorbed by the plant roots and translocated to the other vegetative plant parts. After absorption of copper ion when the underground vegetative parts start decomposing, the grasp of the plants with the soil is loosened automatically and the decaying plants float on the water surface.

If the technique of coppersulphate mud pellets is properly adopted the aquatic vegetation can be successfully controlled.

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APPENDIX I

Laboratory and field experiments conducted with commercial copper sulphate and their results.

A. The chemical applied in water in solution

1952		Cistern 1 Control	Cistern 2 *pH. of water reduced to 6.0+2 ppm copper sulphate solution added	Cistern 3 pH. of water reduced to 6.0+6 ppm copper sulphate solution added	Cistern 4 pH of water reduced to 6.0+ 10 ppm copper sulphate solution added	Cistern 5 With the application of acid pH of water was maintained between 5.0 and 6.0
1. Laboratory experiments conducted to find out the optimal dose. Plant-Hydrilla verticillata (Linn. f.) Royle	After 28 days of treatment	Plants healthy	Plants healthy	Plants healthy	All plants completely decomposed, water became brownish in colour.	Plants healthy and green
	After 54 days of treatment	Plants healthy	Plants healthy	Plants healthy	Plants nil. Water slightly greenish in colour and no odour.	Plants healthy and green
2		Cistern 1 Control	Cistern 2 10.0 ppm copper sulphate solution applied in the water.	Cistern 3 pH of water reduced to 6.0 & 10 ppm copper sulphate solution applied.	Cistern 4 2 ppm copper sulphate solution applied for 5 alternative days and everytime before application pH of water reduced to 6.0	Cistern 5 1 ppm copper sulphate solution applied for 10 consecutive days and everytime before application pH of water reduced to 6.0
The optimal dose of 10.0 ppm applied in variable ways, Plant-Hydrilla verticillata (Lin.f) Royle	After 28 days of treatment	Plants healthy	50% of the plants died and decomposed, the other surviving 50% later showed vigorous growth	Plants completely decomposed	95% of the plants died and decomposed. 5% revised and multiplied.	75% of the plants died and decomposed. 25% revived and multiplied.

Contd..... I

1953 3.		Cistern 1	Cistern 2	Cistern 3	Cistern 4	Cistern 5	Cistern 6
		Control	pH of water reduced to 6.0+ 2 ppm copper sulphate solution applied	pH of water reduced to 6.0+ 4 ppm copper sulphate solution applied	pH of water reduced to 6.0 + 6 ppm copper sulphate solution applied	pH of water reduced to 6 .0+ 8 ppm copper sulphate sol. applied.	pH of water reduced to 6.0+ 10 ppm copper sulphate sol. applied.
Application of the optimal dose 10 ppm repeated on another rooted, submerged plant *Ottelia alismoides*	After 25 days of treatment	Plants healthy	Plants healthy	Plants healthy	Plants appeared 25% damaged but later showed revidal.	80% of plants died & decomposed. 20% of plants survived but appeared somewhat damaged.	95% of plants died & decomposed. The remaining 5% floated in a damaged state
4. Field experiment Cuttack, Orissa.		Nursery pond No. 63 and Nursery Pond No. 65 Paper published in Indian Journal of the Fisheries, Vol. 1, 1954, pp. 204-216					
5. 1955 Field experiment Calcutta, West Bengal		National Library pond. Paper published in Journal of the Asiatic Society, Vol. 1, No. 1, 1959.					

* pH. of water reduced by the addition of concentrated sulphuric acid.

APPENDIX - II

Laboratory and field experiments conducted with coppersulphate and their results.

B. The bottom soil of ponds treated with coppersulphate powder in mud pellets

1964.		
6. Cuttack, Orissa jar experiment plant present = Hydrilla verticillata (Linn.f) Royle. Vallisneria spiralis L.	Jars 1-6 Coppersulphate crystals = Each jar treated with 5 intermittent doses each dose at the rate of 35 Kg/ha, total 175 Kg/ha. The entire volume of water showen increase in copper ion concentration which reacts adversely to other lives present in that environment. In soil the increase in copper ion concentration proportionately was not much. The vegetation absorbed the copper ion and sank to the bottom of the jars but complete destruction was not there.	Jars 7-12 Coppersulphate powder in mud pellets = Each jar treated with 5 intermittent doses, each @ 35 Kg/ha, total 175 Kg/ha. The volume of water at the soil-water interphase only showed increase in copper ion concentration. The increase of copper in the soil was more than what it was after treatment with coppersulphate crystals. The Hydrilla plants died and decomposed completely. The Vallisneria plants showed complete decay of the underground parts and were floating within 15-20 days of treatment, when they were removed from the jars. Regrowth was nil.
Pond experiments. 7. Nursery pond No. 25 8. Rearing pond No. 17	Plants present : Nymphoides cristatum Griseb - 50%, Limnophylla heterphylla Benth = 15%, Naias sp. 5% Hydrilla verticillata(Linn.f) Royle - 13%, Alternanthera sessilis Br-5%, Ottelia alismoides Pers -5% Nymphaea sp.-2%, Cyperus exaltalus Retz-5%. Plants present : Nymphoides cristatum Griseb - 100%	Paper published : Science and Culture, Vol. 36 pp. 159-161, March, 1970.
1965. 9. Kanika Rajbati Pond. The areas of the enrire pond approximatëly 9 acres. Depth of water 12 cm-6 metres. Plants present:Hydrilla verticillata(Linn.f)Royle-50% vallisneria spiralis L-40% Nymphoides cristatum Griseb - 10%	Treated an area of sq.metre 157.5 = 4 intermittent doses applied, each @ 35 Kg/ha, = total 140 Kg/ha. Heavy shower was there for 4 to 5 days from the 4th day from the last treatment Treated an area of sq.metre 157.5 = Near the margin where the depth of water was 1.5-1.8 metre, the area was cleaned by manual labour.	As the treated area was 3½ to 6metre deep, so manual labour could not be applied. The plants of their own when floating were taken out from a boat. The area was completely free of vegetation from the 75th day. The area showed regrowth of vegetation from 35-40days from manual clerance.

10.Killa Moat Section 5	Plants present : Eichhornia crassipes Solms - 55%, Spirodela polyrrhiza L-5%, Nymphoides cristatum Griseb-25% Pistia stratiotes L-5% marginal plant Colocasia antiquorum Schott - 10%			Paper published-Proc.Nat. Acad. Scs.India 41(B)II 1971
11.WEST BENGAL 1967. Aquaria experiment	To find out the release of copper ion from treated soil			Paper published : Indian Agricultusit, Vol. XII, No. 2, July, 1968
12.Bantala, Salt Lake, Sewage irrigated nursery pond	Plants present : Eichhnrnia crassipes Solms - 50%, Hydrilla verticillata (Linn.f) Royle-25%, Vallisneria spiralis L-25%			Papeer published - Jour. As Soc Vol. XIV Nos. 2-4, 1972
13.Bantala, Salt Lake, Sewage irrigated canal	Plants present : Eichhornia crassips Solms - 50%, Cyperus articulatus Linn. 40% Hydrilla verticillata (Linn.f) Royle-10%			
14.Kholisa beel, Nadia Dist. The area approximately 400 bighas. In summer depth of water 70-120 cm and in monsoon 180-300 cm.	Plants present : Volume choked with Hydrilla verticillata (Linn.f) Royle Ceratophyllum damersum L. Ottelia alismoides Pers, Nymphaea rubra Roxb., Cyperus spp. Surface checked with Eichhornia crassipes Solms, Pistia stratiotes Linn., Spirodela polyrhiza L. Marginal plants: Colocasia antiquorum Schott, Marsilea quadrifoliata L.	Small areas selected for treatment 1. 195 sq. metre = Treated as it is shoked with vegetation. 2. 195 sq. metre = Treated 24 hours after manual clearance, only Hydrilla 5% and a few floating plants present. 3. 300 sq. metre = Treated 4 months after manual clearance, but again the area choked with similar vegetation.	Each area separately treated with 4 intermittent doses, each dose @ 35 Kg/ha total Kg/ha. 140	Success 1 = 40% 2 = 90% 3 = 75%

CONTD .... NEXT PAGE

15.1968 Ramrajatolla pond 7 km from Howrah Station. Area 1,110 sq. metre. Depth varying from 61-366 cm.	Plants present : Rooted submerged = *Hydrilla verticillata* (Linn.f) Royle, *Potamogeton pectinatus* Linn, Naias sp. Rooted marginal = *Jussiaea repens* Linn, *Ipomaea aquatica* Forsk *Marsilea quadrifolaiata* L. Surface floating= *Eichhornia crassipes* Solma	6 intermittent doses applied : 1st dose @ 3.6 Kg/ha 2nd " @ 3.6 Kg/ha 3rd " @ 3.6 Kg/ha 4th " @ 35 Kg/ha 5th " @ 15 Kg/ha 6th " @ 35 Kg/ha Total 95.8 Kg/ha	After treatment when 75% of the vegetation were cleared the fish farmer netted the pond, caught all the fish and sold them. Later he did not take the trouble of keeping the pond as the lease period on which he took the pond was ending.	
16.Ramrajatalla pond 494 sq. metre in area. Depth varying from 106.5-122 cm.	Plants present : Surface completely covered with *Eichhornia crassipes* Solms. Volume of water choked with *Ottelia alismoides* Pers.	Paper published :	Proceedings of the National Academy of Sciences, India, 41(B)III, 1971	
17.Chakrabaithak Pond in Lakes, Calcutta. Area of the pond approximately 20,250 sq. metre. Area treated 2,100 sq. metres.	Plants present : Rooted emergent = *Nymphoides cristatum* Griseb-2% Rooted marginal = *Scirpus articulatus* Linn. 70%, *Colocasia antiquorum* Schott 2%, *Cyperus exaltatus* Retz 4%, *Jussiaea repens* Linn. 2% Rootless, submerged, floating = *Ceratophyllum demersum* L. 20%	4 intermittent doses applied, each @ 35 Kg/ha, total 140 Kg/ha.	In thirty days from the last dose, all the plants including *Scirpus* could be re- manual labour Later regrowth of *Scirpus* and *Cyperus* for which the marginal area was treated, was nil.	Success 100%

18.1969 Gamla pond in Botanical Garden, Sibpore. Area 930 sq. metre	Plants present : On the bottom soil 4-5 cm thick layer of Cladophora sp. Rooted submerged:Ottelia alismoides Pers 20%, Vallisneria spiralis L. 20%, Potamogeton pectinatus L. 15%, Hydrilla verticillata (Linn.f) Royle 15% Rooted emergent:Nymphoides cristatum Griseb.10% Rootless, submerged, floating Ceratophyllum demersum L. 20%	4 intermittent doses applied each @ 35 Kg/ha total 140 Kg/ha.	Within 49 days from the last dose except Hydrilla and Ceratophyllum which decomposed within the pond, all the other plants were uprooted and floating when they were removed by manual labour. The pond remained weed free.	Success 100%
19.Kind Lake, Botanical Garden, Sibpore Area approx. 30,717 sq. metre. Area treated 13,932 sq. metre.	Plants present in the treated area : Rooted submerged : Hydrilla verticillata (Linn.f) Royle, 20%, Vallisneria spiralis L. 20%, Ottelia alismoides Pers 6%, Potamogeton pectinatus L. 10% Rooted emergent:Nymphoides cristatum Griseb. 10% Nymphaea rubra Roxb. 7%, Nymphaea lotus L. 7% Rootless, submerged, floating Ceratophyllum demersum L. 20%.	4 intermittent doses applied; 1st dose @ 35 Kg/ha. 2nd dose @ 10 Kg/ha. 3rd and 4th dose each @ 15 Kg/ha. Total 75 Kg/ha.	Except the Nymphaea spp. the other plants were uprooted and they were taken out by manual labour, Nymphaea sp. as much possible were also removed by manual labour. Ottelia, Nymphaea sp. showed healthy regrowth.	Success 65%
20.1970 King Lake, Another area treated 1,609 sq.metre.	Plants present : Rooted submerged:Hydrilla verticillata (Linn.f) Royle 30% Vallisneria spiralis L. 25%. Rooted emergent Nymphaea rubra Roxb. 25%, Nymphoides cristatum Griseb 10% Rootless, submerged, floating Ceratophyllum demersum L. 10%	3 intermittent doses applied: 1st dose @ 35 Kg/ha. 2nd dose @20 Kg/ha. 3rd dose @ 20 Kg/ha. Total 75 Kg/ha.	Hydrilla and Ceratophyllum destroyed 100%, regrowth nil. Vallisneria, Nymphoides 50% and Nymphaea 25% affected. These plants showed healthy regrowth.	Success 65%

APPENDIX III

Name of the treated area	Whether part or entire area treated.	Area treated sq. m.	Depth of water, metre	Rate of treatment kg/ha	Number of instalments applied	Maximum copper ion in water ppm. initial	Maximum copper ion in water ppm. increase	Maximum copper in soil mg/100 gms of soil: Water soluble Initial	Water soluble increase	Acid soluble initial	Acid soluble increase	Percentage of success.
1	2	3	4	5	6	7	8	9	10	11	12	13
1. Cuttack Nursery Pond No. 25.	Entire pond treated Heavy rains during treatment and also later.	224	2-3	45 - 4 doses Total= 180 kg/ha	4	Surface = .01 Bottom = .01	.02 .03	.1	3	.2	14	100
2. Cuttack Rearing Pond No. 17.	A small area from one side of the entire pond was treated.	966	2-2¼	35 - 5 doses Total= 175 Kg/ha	5	Surface = .01 Bottom = .01	.3 .35	.1	3	.2	12	100
3. Cuttack Kanika Raj - bati Pond.	A small area, near about the middle of the entire pond, treated.	157½	6-6½	3[illegible] - 4 doses Total= 140 Kg/ha	4	Surface = .01 Bottom = .01	.25 .45	.1	3	.2	7	100
4. Calcutta Chakraba-ithak Pond.	A small length along with 2,100 the margin of the whole area.	2,100	1-1½	35 - 4 doses Total= 140 Kg/ha	4	Surface = .01 Bottom = .01	.45 .5	.1	9	.2	13.5	100
5. Sibpore Botanical Garden, Gamla Pond, conncetion is there with Ganga river.	Entire pond treated.	930	3½-5½	35 = 4 doses Total = 140 Kg/ha	4	Surface = .01 Bottom = .01	.68 .68	.1	1.5	.2	14	100
6. Bantala, Sewage fed. fishery.	Entire pond treated.	312	2-2½	35 - 3 doses Total = 105 Kg/ha	3	Surface = .01 Bottom = .01	.28 .32	.1	0.5	.15	12	100

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1	2	3	4	5	6	7	8	9	10	11	12	13
Bantala, Sewage fed fishery.	A small portion in the middle of a canal treated without erecting bundh on either side.	185	2-2½	35 - 3 doses Total= 105 Kg/ha.	3	Surface = .01 Bottom = .02	.28 .32	.1	0.5	.15	12	100
Ramrajatolla. Freshwater Pond.	Entire derelict pond treated.	1,110	5-6	3.6 Kg = 3 doses. 35 Kg = 2 doses. 15 Kg = 1 dose. Total = 95.8 Kg/ha.	6	Surface = .01 Bottom = .01	.3 .5	.1	1.4	.2	11	75
Ramrajatolla. Freshwater Canal.	Entire canal treated	494	2	35 Kg = 2 doses. 10 Kg = 2 doses. Total= 90 Kg/ha.	4	Surface = .01 Bottom = .01	.6 .6	.1	1.6	.2	11	100
Sibpore, Botanical Garden. Kind Lake connection is there with Ganga river.	One area of the big lake treated.	13,932	2-4	35 Kg = 1 dose. 10 Kg = 1 dose. 15 Kg = 2 doses. Total= 75 Kg/ha.	4	Surface = .01 Bottom = .01	.08 .16	.1	1.5	.2	6	75% but a few months after regrowth was observed.
Sibpore. Botanical Garden. Kind Lake connection is there with Ganga river.	Another area of the big lake treated.	1,609	2-3	35 Kg = 1 dose. 20 Kg = 2 doses. Total= 75 Kg/ha	3	Surface = .01 Bottom = .01	.06 .08	.1	1.2	.2	2.5	75% but regrowth was quick, especially of <u>Nymphaea</u> sp.
Cuttack. Most Section 5.	An area of the most treated, this section is connected with the adjoining section.	1,068	3-3½	20 Total 20 Kg/ha.	1	Surface = .01 Bottom = .01	.05 .06	.1	.08	.2	.85	100