SOLAR HEATER FOR CURING TOBACCO
Part I: Overview and Theory.

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ABSTRACT

This is a two part paper. In part one of the paper, an overview on the use of packed beds on heat collectors to be used in natural convection systems is presented. A brief theoretical background and literature review has also been presented. Theoretical analysis and performance equations are presented in detail. Two types of absorbers are proposed for investigation. The first one will be with flow below the absorber and the other with flow "through" the absorber. These shall be compared with the conventional flat plate collector. For comparing the performance, packings of different materials, shapes, and sizes will be considered. In part II of the paper, testing procedure, results and their analysis will be presented. This will include interpretations for collectors suitability for use in driers for curing tobbaco.

INTRODUCTION

To cure a hectare of tobacco requires a hectare of savanna woodland and tobacco growing is expanding in Tanzania at the rate of 20 percent annually, and the savanna is disappearing at the same rate (Mnzava, 1981; Mwandosya and Luhanga, 1985).

The current practice of curing tobacco in Tanzania is by use of barns. The drying of tobacco occur inside a barn whereby the flue gases from a furnace are circulated through a flue-pipe made from galvanized iron sheet, laid near the floor, in a 'T' or 'U' configuration ending in a chimney on the top of the barn. The furnace is usually built on the outside, adjacent to the barn. The fuel burnt in the furnace is mostly wood. The curing process is almost exclusively based on natural convection and radiation heat transfer, through the pipes. Siddiqui and Rajabu (1992) calculated the barn efficiency and found it to be of the order of 0.5 percent.

Experience in Tanzania has shown that close to 60 m^3 of fuel wood is expended when curing the yield from one hectare of tobacco, about 450 kilograms (kgs). Therefore one hectare of tobacco crop per year requires approximately one hector of woodland for curing (Mnzava, 1981: Mwandosya and Luhanga, 1985). Tanzania has capacity to process more than 51 million kilograms of tobacco annually. At present, it processes only 36 to 40 percent of this capacity, one of the major reasons being the inadequate supply of wood energy. For this important and expanding industry to flourish, it would require 3.36 million m^3 or 114,000 hectares of wood land to be cleared annually.

Natural regeneration of the forests is difficult due to the mode of cultivation. Much of the tobacco farming in Tanzania is based on shifting cultivation. When the villager clears forest land for planting tobacco, the trees are usually completely destroyed by burning rather than stored for tobacco curing. A separate area is normally harvested, especially for the curing process.

Possible solutions to avert the deforestation crisis are tree-planting, the use of alternative fuel resources such as coal, hydroelectricity, oil etc. or to improve the barn efficiency (Kadete, 1989). In order to improve the efficiency of the traditional tobacco curing barn, Mwandosya and Luhanga (1985), recommended the application of coal in addition to fuel wood. They also recommended reforestation in tobacco growing areas.

The reforestation efforts seem to be unrealistic since the reforestation program is proceeding very slowly. Also due to the high investment costs required to establish coal mines and extract coal, and the infrastructure investment required in its transportation and distribution, it will take long before coal can be utilized economically in tobacco curing (Kadete, 1989). Kadete (1989) suggested the use of an electrical flue that consists of a steam source and an electrostatic ventilator with an efficiency of the order of 39 percent. However his argument that use of such a system in tobacco curing will justify the economic costs required for rural electrification seems to be too ambitious.

Siddique and Rajabu (1992) gave the following recommendations aimed at improving the efficiency of the tobacco curing barns:-

1. The furnace design needs to be optimized to minimize heat losses;

2. The effect of flue pipe diameter on the mode and magnitude of heat transfer needs to be studied;

3. The feasibility of replacing wood fuel with coal needs to be studied, along with the effects of CO & CO_2 emissions on the environmental pollution.

4. The extent to which solar heating can supplement conventional heating thereby saving fuel, needs to be studied.

Mulungu (1994) has worked on recommendation 1 whilst Siddiqui and Rajabu (1992) worked on the second recommendation and both preliminary results indicates that the efficiency of the tobacco barn can be improved from 0.5 percent to about 10 percent by using improved furnace design. Problems on use of coal have been discussed above.

Solar energy on the other hand, seems to be the only energy alternative which is available in abundance. Over the past three decades, research and development activities have accelerated to such an extent that it may be possible that by the turn of this century solar energy will be a major source of energy (Sayigh, 1980). This may well be advantageous since, on the whole, solar energy does not damage the environment and is abundant in an area of great need, the developing countries.The idea of using the energy radiated by the sun is not new in Tanzania. Solar energy has been in use in a number of ways which can be expressed as low grade utilization of solar energy.

A solar assisted tobacco curing barn is one solar energy utilization method which could contribute towards one of the efforts to avert the deforestation crisis.

THEORETICAL BACKGROUND

Globally, solar drying technology has been developed steadily in recent years and new types of solar driers and systems have been reported. The function of a solar process in a heat system is to collect energy from the sun, transfer it to the desired location, and convert it into a usable form. The major components to carry out these function are:

1. solar energy collectors
2. heat transfer fluids
3. piping or duct work
4. pumps and
5. controls.

The collectors are the most expensive and most critical determinants of the systems performance. A need therefore exists of developing a suitable collector for use in a solar process heat system to be used for tobacco curing.

The design of a solar energy system is concerned with obtaining minimum cost energy. Thus it may be desirable to design a collector with an efficiency lower than is technologically possible if the cost is significantly reduced. In other words, the ultimate goal in solar energy or any form of energy-utilization is to decrease the cost of energy collected in price per unit energy produced. The cost effective design may not necessarily be the one using the most efficient solar collector, it is rather a combination of high efficiency, low fabrication, installation and operation costs, and other practical aspects that are related to the specific application in mind. Most of the tobacco curing barns are found in areas where there is no electric power supply. With this in mind and also considering the fact that most of the farmers who own these barns are financially incapable of installing prime movers for their barns, it will be impractical to consider developing driers which use blowers. The driers to be considered should be those using natural convection for their operation.

The Collector

A solar collector is a special kind of heat exchanger that transforms solar radiant energy into heat. One of the most common type of these is a flat plate collector. The important parts of a conventional flat plate collector include a surface with a high emissivity, normally a black coated plate, which absorbs solar energy and converts it into heat. This plate is known as the absorber. Embedded or included to the absorber plate are fluid channels positioned below or above the absorber for carrying a heat transferring fluid. It transfers the heat from the absorber to the utilization system.

In order to minimize both convection and radiation heat losses, to the atmosphere, a transparent cover is incorporated over the solar absorber surface. Also, for reduced heat losses to other sides of the collector, an appropriate insulation becomes an integral part of the collector.

The Absorber

The most important component of a low temperature collector is the absorber. The absorber absorbs most of the solar radiation, gets heated and in turn starts radiating long wave thermal radiation. For proper function, the absorber should have maximum absorptivity (fraction of the total incident radiation that is absorbed). The energy absorbed is distributed in a way that part of it is emitted as long wave radiation to the surroundings while the rest is lost convectionally to the surrounding and as heat transfer to the fluid transport medium. For efficient performance, the radiative and convective losses should be minimal.

Air Heater Designs

Several designs of solar air heaters have been developed over the years in order to improve their performance. There has been significant interest in packed- bed absorbers for air heating solar collectors because of some distinct advantages over that of flat-plate collectors. Packed bed matrix absorbs solar radiation "in depth" and has high ratio of heat transfer area to volume and high heat transfer capability resulting in relatively low absorber temperature. This will decrease the heat losses from absorber to ambient air and hence result in an increase in the efficiency of the collector (Sharma *et al*, 1991).

The advantages of packed bed absorbers are:-

- the solar radiation penetrates to greater depths and is absorbed gradually depending on the matrix density. The cool air stream introduced from the upper surface of the matrix is first heated by the upper layers which are cooler than the bottom layers. The air stream warms up, while traversing the matrix layers. The lower matrix layers are hotter than the upper ones, therefore the air stream can effectively transfer heat from the matrix, and

- the pressure drop for the porous matrix (packed bed) is usually lower than the non porous absorber with flow behind the plate since flow per unit cross-section would be much lower. Although the matrix hinders the flow, the pressure drops reported for porous matrix absorbers are still lower than for the non porous absorbers.

Under this category, absorbers having a bed packed with iron shavings and iron wires (Singh, 1978), blackened wire-screen matrix (Sharma *et al.*, 1991), different materials, shapes and sizes with different void fractions (Choudhury and Garg, 1993) have been reported. A concept of using crushed glass layers to absorb solar radiation and heat the air can also be suggested. A porous bed made by forming layers of broken bottles (bottom dark top clear glass) was proposed by Selcuk (1980) but has not yet been investigated. These studies suggest these types of air heaters to have superior performance than air heaters using flat plate absorbers.

The advantage of using packed beds in solar collectors is the rapid increase of heat exchange resulting from large surface area of the packing material and augmentation of impeding air flow (close to turbulence) path through the bed. Exclusively, the work done on solar heat collectors with packed beds, have been considering the incorporation of a pumping power. However, with ingenuity, it is possible to use packed beds on heat collectors to be used in natural convection systems. It is the purpose of this two part paper to firstly give an overview for such a configuration and secondly to report on the performance of such a designed solar heater operating under these principles. The results from this will be interpreted for its suitability for use in tobacco curing.

THEORETICAL ANALYSIS.

An extensive work on the performance of air-heating collectors with packed air flow passage has been done by Choundury and Garg (1993). From these studies, it is being suggested that the use of non absorbing packing in the air flow channel beneath the absorber and absorbing packing beneath the glass cover (without absorber) in the solar air heaters helps to improve efficiency significantly, due to the increased resident time and near turbulence flow provided by the packing in the air flow passage. On earlier experiments, investigation was conducted on two different types of air heaters , one comprising a cover plate, an absorber, and a back plate with packing in the air flow passage between the absorber and the back plate, and the other consisting of two glass covers and a back plate with black-painted (absorbing) packing in the flow passage between the inner glass cover and the back plate. Results indicated that, air heater with two glass covers performed better at low air flow rates. At increased air flow rates, the efficiency of single cover absorber increases significantly as compared to that of two covers. However both collectors with packed air flow passage performs much better than the flat plate collector.

With this last observation, and bearing in mind that a design for natural convection operation, is sought, then a heater with low air flow rates, and with two transparent covers with a back plate and packing in the flow passage is considered for design in natural convection systems.

Performance Equations.

The performance of a solar collector is described by an energy balance that indicates the distribution of incident solar energy into:-

- useful energy gain
- thermal losses
- optical losses

In a steady state, the useful energy output of a collector is the difference between the absorbed solar radiation and the thermal losses, this is expressed as in the following equation.

$$Q_u = A_c[S - U_L(T_{s,m} - T_a)] \qquad (1)$$

As the mean absorber plate temperature is a function of collector design, incident solar radiation and entering fluid conditions, it presents a problem in determining this temperature. To circumvent this, the useful energy gain is expressed in terms of inlet fluid temperature and the collector heat removal factor which is either evaluated analytically or measured experithe glass cover (without absorber) in the solar air heaters helps to improve efficiency significantly, due to the increased resident time and near turbulence flow provided by the packing in the air flow passage. On earlier experiments, investigation was conducted on two different types of air heaters , one comprising a cover plate, an absorber, and a back plate with packing in the air flow passage between the absorber and the back plate, and the other consisting of two glass covers and a back plate with black-painted (absorbing) packing in the flow passage between the inner glass cover and the back plate. Results indicated that, air heater with two glass covers performed better at low air flow rates. At increased air flow rates, the efficiency of single cover absorber increases significantly as compared to that of two covers. However both collectors with packed air flow passage performs much better than the flat plate collector.

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$$\eta = F_o[(\tau\alpha)_e - U_L \frac{(T_o - T_i)}{I}] \tag{6}$$

where $\mathbf{F_o}$ is the heat removal factor referred to the out let temperature. Values for $\mathbf{F_o}$ and $\mathbf{U_L}$ are given in the work by Duffie and Beckman (1980) and again by Parker *et al.* (1993). Three parameters **[F_o,($\tau\alpha)_e$)e, and U_L]** are needed to describe the thermal performance of a collector. Therefore, control of thermal performance exercised by the designer must be achieved through changes in these three parameters.

The effective transmittance-absorptance product ($\tau\alpha)_e$ can be computed using the transmittance and absorptance of the absorber plate. The computation requires appropriate heat transfer coefficients from the literature with estimated or measured environmental data and estimated temperatures in the collector.

Performance of a collector can however be expressed by another equation, containing the temperature gain produced by the collector (Biondi *et al.*, 1988).

$$\eta = \frac{GC_p(T_o - T_i)}{I} \tag{7}$$

Eqn (6) indicates that a plot of efficiency, η against **$(T_o$-$T_i)/I$** will result in a straight line whose slope is **F_oU_L** and ordinate axis-intercept is **F_o** $(\tau\alpha)_e$.

Thus eqn. (6) and (7) can be represented by a single diagram having the same quantities as the abscissa and the ordinates (Biondi *et al.*, 1988; Sharma *et al.*, 1991). For a given collector, this diagram shows the typical performances η and **(T_o - T_i)** versus the variations of **I** and **G**. This is the most suitable way to describe the working behavior of air collectors and is the one which shall be employed later.

EQUIPMENT AND INSTRUMENTATION.

Collector Design

Several significant effects of collector designs on the thermal performance of packed bed air-type collectors are illustrated in the literature. Biondi *et al.* (1988) presents a very helpful design analysis of solar air heaters of conventional design. The quoted work introduces the geometric coefficient (k) of a collector which can be used in experimental tests for grouping geometrically similar air heaters. Also provided are diagrams which can be used as project nomograms in real situations and useful for both a comparison of the performances of the various types of collectors and for selecting the type of construction which best satisfy specific conditions of use.

Choudhury and Garg (1993) made available computations of the pumping power expended in pumping air through collectors to estimate the net or the effective gain of the systems for air channels of different lengths and depths, having different air flow rates with and without packing of different materials shapes and sizes. It is anticipated that based on these studies and other relevant literature available, an appropriate design can be arrived at.

Since it is convenient and economical to use a smaller collector in experimental work than the actual one, then a scaling down procedure has to be considered.

On this investigative work, two types of absorbers are proposed. Of these the first one will be with flow below the absorber and the other with flow "through" the absorber.These shall be compared with the conventional flat plate collector. The three air-heater configurations considered for comparative investigation are shown schematically in Figs 1(a), (b), and (c) as type I, II, and III.

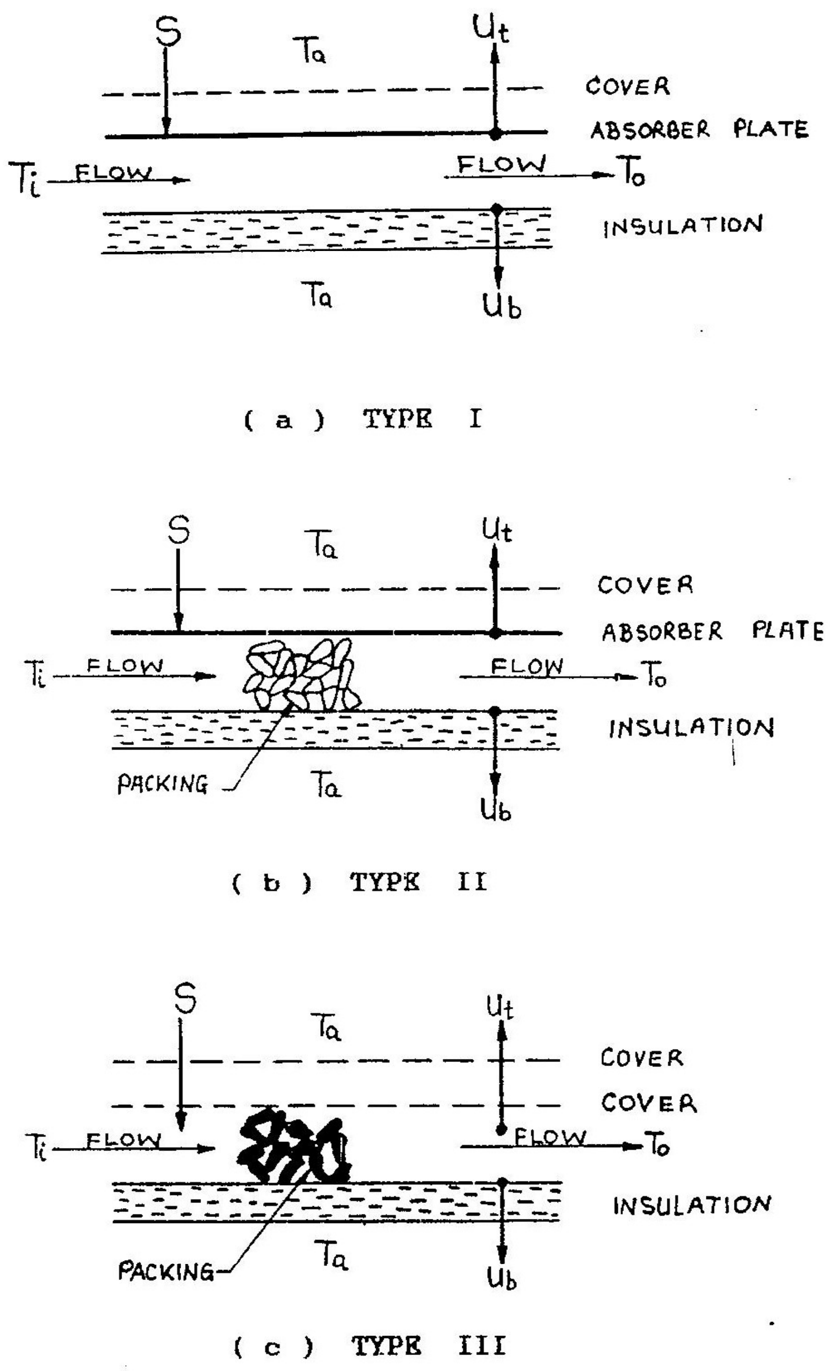

Fig. 1: Types of Collectors

Figure 1(a) shows the type I solar collector which is of conventional design with a single transparent cover and air flow below the absorber. This is used for comparison with those of the packed bed collectors.

Figure 1(b) shows the type II collector, comprising a transparent cover plate, an absorber, and a back plate with packing in the air flow passage below the absorber. The proposed packing which should be non-absorbing are:

- broken clear glass or bottles of different sizes
- clear plastic materials of different sizes
- colorless marble

Figure 1(c) shows the type III,air heater consisting of two transparent covers and a back plate with absorbing packing in the flow passage below the inner cover.
The proposed absorbing packing for this type of heater are:

1. broken colored bottles or glass of different sizes
2. charcoal
3. black colored marble
4. rubber tire pieces of different sizes
5. carbonized rice husks

EXPERIMENTAL SET UP

The heat collectors for the test purpose consists of three collector units (Fig. 2) arranged side by side. These collectors are mounted in a frame and in a plane of fixed slope to the latitude of the testing location.

Figure 2 shows the schematic diagram of the overall flow circuit. The collectors will operate under natural convection. At the end of each collector, a flow meter is mounted. Atmospheric air is drawn through entrance (1) before passing through the collectors. The air then proceeds through flow meters before exhausting to the atmosphere.

The outlet of each collector is closed through a suitable angle for connection to a 102mm (4") round pipe. A calibrated orifice, and a valve to control air flow are placed in that order in the exit duct. Mass flow rate of air through the collectors is measured by the orifice meters of standard specifications. The flow rate is controlled by a valve at the outlet duct. Thermocouples are used to measure the air and absorber temperatures at different locations. Solar radiation flux shall be recorded using a pyranometer. In part II, testing procedures, results and their analysis will be presented.

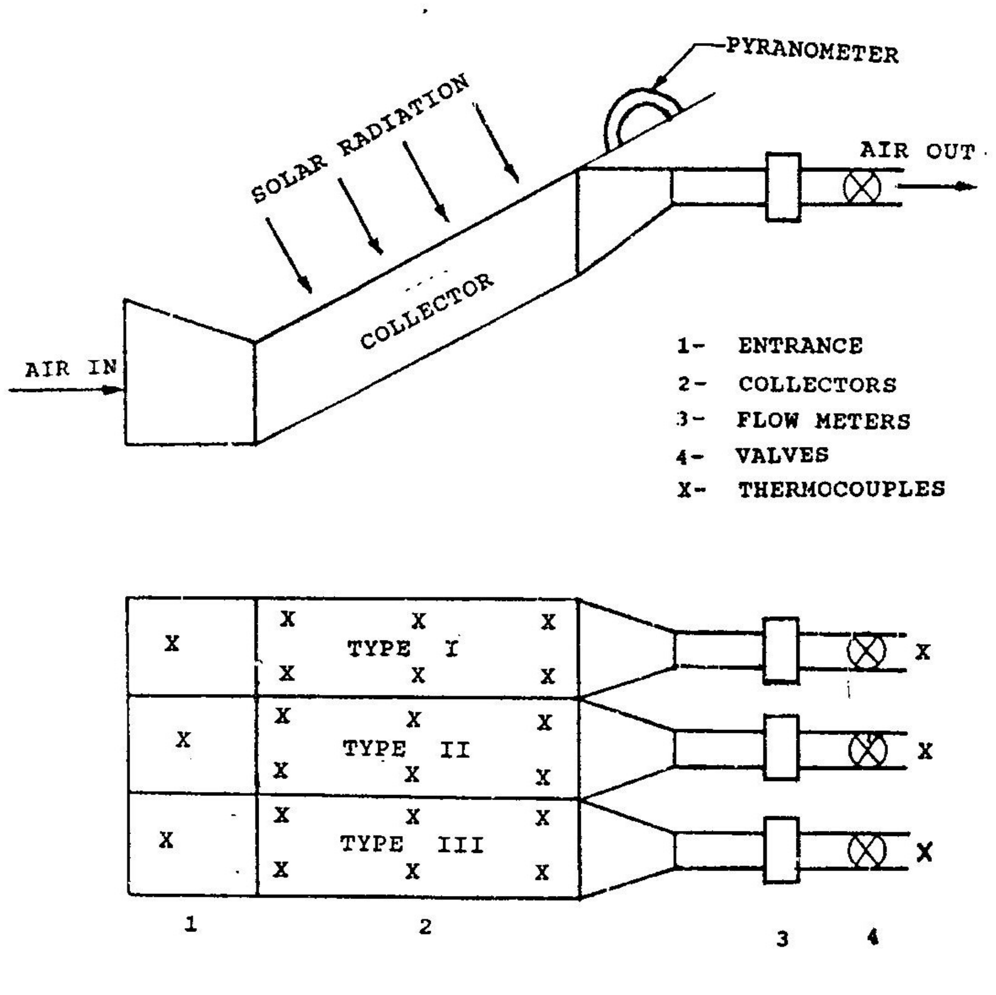

Fig. 2: Experimental set up

NOMENCLATURE

A	heat transfer area, m^2
A_c	collector area, m^2
C_p	specific heat of packing material, J/kg ^oC

F_o heat removal factor related to outlet temperature
F_R heat removal factor related to inlet temperature
G air mass flow rate per unit collector area, kg/sec.m2
I total solar energy incident upon plane of the collector per unit time per unit area, W/m2
Q_u useful heat output, W
S the absorbed solar radiation = (,)$_e$ I, Wm-2
T_a ambient air temperature, °C
T_i inlet air temperature, °C
T_o outlet temperature of air, °C
$T_{s,m}$ average temperature of the aosorber surface, °C
U_L collector overall loss coefficient, W/m2.°C
collector efficiency, %
$()_e$ effective transmittance-absorptance product for cover-absorber combination

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EXPERIMENTAL INVESTIGATION ON THE USE OF NATIVE BIOMASS AS BIOSORBENTS FOR METAL POLLUTANT REMOVAL

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ABSTRACT

Waste water treatment is a permanent task. Many novel techniques have emerge in recent years and one of them is using biomass in removing heavy-metals. In this research screening and preliminary optimization experiments have identified different types of abundant biomass which can accumulate heavy metals such as Fe^{3+}, Co^{3+}, Cu^{2+} and Cr^{3+} from effluent. Cystoseira Myrica has a high uptake of Cr^{3+} while Sargassum Polycystum has been found to have a high uptake of Fe^{3+}. Observed biosorption kinetics shows rapid initial stage, followed by slower second stage and the amount of material adsorbed increases linearly as its concentration in the solutions increases.

INTRODUCTION

Background

In recent years, major efforts have been undertaken to develop waste water treatment techniques which are effective at removing both organic and inorganic contaminants so that waste water discharges, and water quality standards can be met [1]. This is becoming an even more of concern as the need for recycling of industrial waste water, and recovery and concentration of useful metals.

Biosorption of heavy metals by microbial cells is recognised as a potential alternative to existing technologies for the recovery of heavy metals from industrial waste streams and natural waste waters [2].

While research on novel techniques using immobilized biomass continue elsewhere [3], it may worthwhile for Africa to look at the potential of the abundant native biomass for use as biosorbents which are cheap but effective.

Mechanism for metal uptake

Biosorptive potential of biomass is attributed to either biosorptive uptake by non-living biomass or bio-accumulation by living cells. In facts, both mechanisms may occur Simultaneously, albeit at different rates [3]. In this work, biosorptive uptake using non-living (inactive) biomass is chosen for investigation because no toxicity problems may be encountered in non-living biomass and the process is not governed by physiological constraints. The use of inactive biomass also eliminates the possibility of biodegradation as a removal process [4]. Furthermore, there is evidence from literature [5] that, with respect to equilibrium, biosorption occurs to the same extent in living cells as in dead cells.

EXPERIMENTAL

Preparation of Material

Identification of species

Six different types of seaweeds specimens used in the study identified with the help of Department of Botany, University of Dar es Salaam as *Ulva Racticulata (I), Ulva fasciata (II), Crystoseira Myrica (III), Sargassum Polycystum (IV), Gracilaria Grassa (V), and Amansia Species (VI)* (numbers in brackets indicates coding used in this work).

The seaweeds used in the study were picked by hand during low tides, packed in plastic bags and rinsed thoroughly with fresh water to remove surface salts and debris. The rinsed algae were then dried in an oven at temperature of 100°C and then ground in a mortar to the size of about 60 US mesh and stored in stoppered flasks. Activated carbon (80 US mesh) used for comparison was obtained from purchased stock in Chemical Engineering Laboratory.

AAS Calibration

Concentration measurements were done using an Atomic Absorption Spectrometer (AAS Pelkin Elmer Model 3100 - Flame ionizer type). The use of AAS requires calibration curve for each metal of interest to be developed. Standard solutions of metals of interest (Cr^{3+}, Cu^{2+}, Co^{3+} and Fe^{3+}) were prepared at concentrations 1, 3, 5, 7, and 10 ppm. The AAS was then programmed to read concentration directly in ppm. During measurements, the filtrate was diluted to within the standard concentration selected. Detail of calibration may be found elsewhere [6].

Adsorption Experiments

An aqueous solution containing 20%w.w. of the element of interest was prepared. 50mls of aqueous solution was measured and put in 250ml flask. 2g of powdered adsorbent was added in the solution and then shaken thoroughly. The mixture was kept at 30°C for 24 hours in a gantry shaker at medium intensity mixing. Samples were taken for analysis after very hour, in the first 5 hours and after 24 hours the mixture was filtered and the filtered and the residual metal in the filtrate was analyzed using AAS.

Time Course of Adsorption

50 mls of aqueous sample of metal of interest is contacted with 2g of the corresponding adsorbent. The mixer was then placed in a gantry shaker and mixed at medium intensity. Samples were analyzed for free metal after the every 30 minutes using AAS.

Contact Density

50 mls of aqueous solution of the metal of interest was mixed with 0.5, 2, 4, 6, 8, and 10g of adsorbent separately. The sample was then shaken for 30 minutes in gantry shaker and residual metal concentration measured using AAS.

RESULTS AND DISCUSSION

Screening Experiments

From screening results in Figs. 1 through 4, shows that there is a significant difference in the biosorptive capacities of the different samples for the various aqueous species contacted. Fig. 1 shows that there is potential for Fe^{3+} removal by most of the native biomass tested. But in further experimentation in this study *Sargassum Polycystum (IV)* showed higher potential for Fe^{3+} removal by giving the lowest residual metal content during the first two to three hours of contacting. From fig. 2, *Cystoseira Myrica (III)* shows higher potential for chromium removal since it gives a minimum residual metal (comparable to activated carbon). Fig. 3 shows that *Cystoseira Myrica* and *Sargassum Polycystum* gives an appreciable reduction in residual concentration of copper ions in solution. From Fig. 4, we see again that *Sargassum Polycystum* gives an appreciable reduction of Co^{3+} ions from aqueous solution.

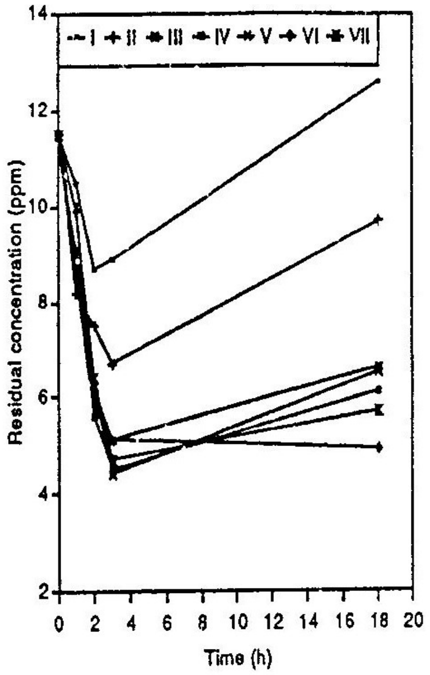
Time Course of Adsorption and Contact Density

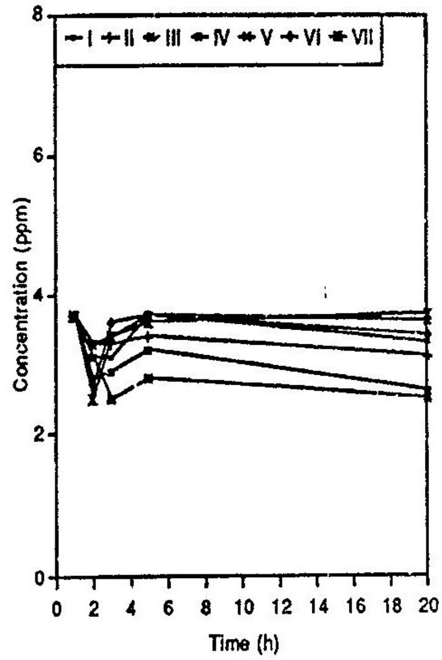
Fig. 5 shows that *Cystoseira Myrica* has a rapid uptake of Cr^{3+} and Cu^{2+} during the first 30 minutes of contact. Biosorption then continues slowly, and reaches equilibrium after two hours for the case of chromium while copper uptake increases slowly up to 7.5 contact hours. *Sargassum Polycystum* shows a rapid uptake of Fe^{3+} during the first 30 minutes of contact, followed by a period of slow uptake, reaching equilibrium before 2 contact hours have passed.

In Fig. 6 it is shown that *Cystoseira Myrica* has rapid Cu^{2+} uptake when contacted in 50 mls, 8ppm/6g adsorbent and biomass loading of 6g in 50mls, 8ppm Fe^{3+} with *Sargassum Polycystum* as adsorbent is optimal.

Effect of External Metal Concentration

Fig. 7 shows that when the concentration of metals in the solution was increased keeping mass of adsorbents constant the amount of metal adsorbed per gram of adsorbent increases linearly. The trend is similar to the results reported by Freer et at (1989) for Uranium adsorption by Pinus Radiata D. Don.


I II III IV V VI VII
Residual concentration (ppm)
Time (h)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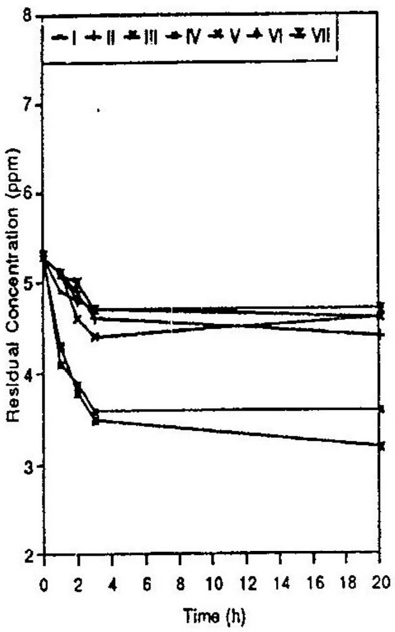
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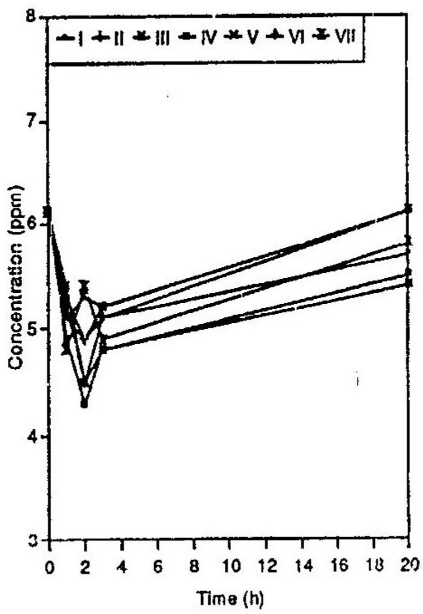
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Concentration (ppm)
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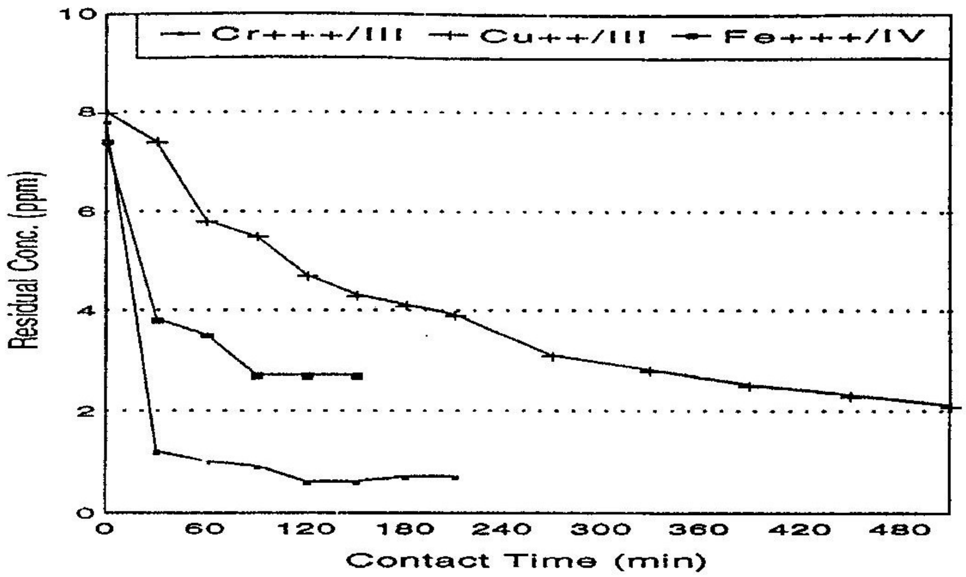
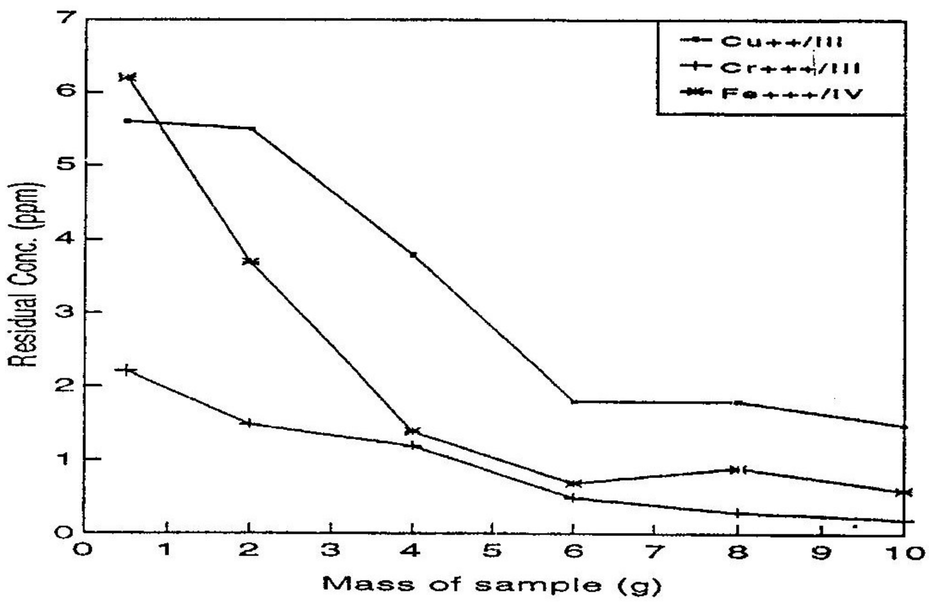
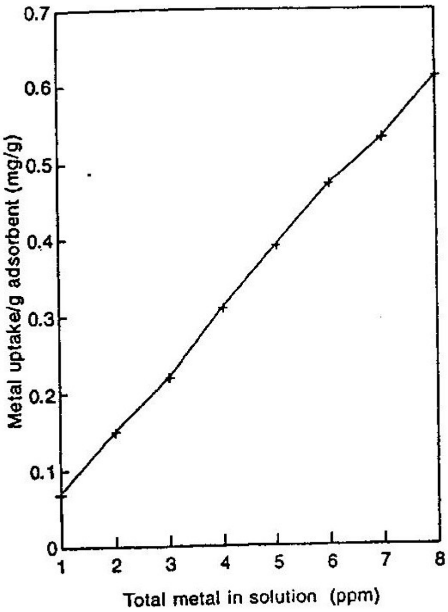
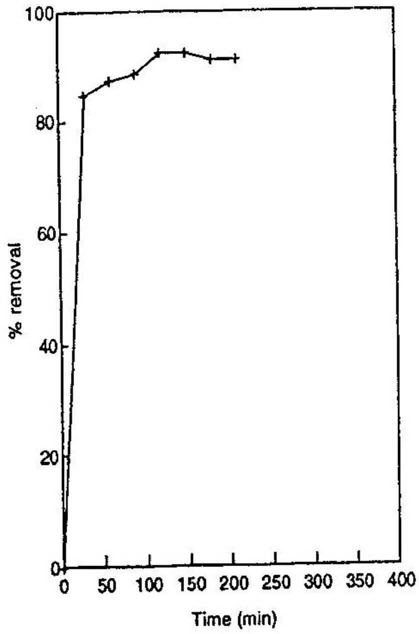
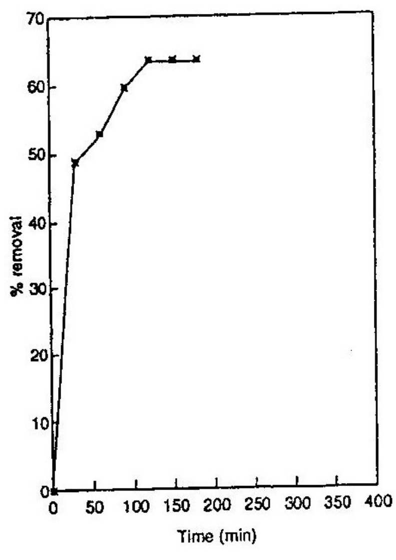
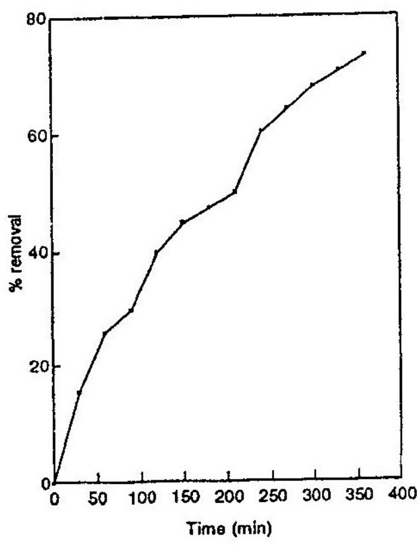

Cr+++/III
Cu++/III
Fe+++/IV
Residual Conc. (ppm)
10
8
6
4
2
0
0
60
120
180
240
300
360
420
480
Contact Time (min)


Cu++/III
Cr+++/III
Fe+++/IV
Residual Conc. (ppm)
7
6
5
4
3
2
1
0
0
1
2
3
4
5
6
7
8
9
10
Mass of sample (g)


Metal uptake/g adsorbent (mg/g)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 2 3 4 5 6 7 8
Total metal in solution (ppm)


% removal
100
80
60
40
20
0
0 50 100 150 200 250 300 350 400
Time (min)


% removal
70
60
50
40
30
20
10
0
0 50 100 150 200 250 300 350 400
Time (min)


% removal
80
60
40
20
0
0 50 100 150 200 250 300 350 400
Time (min)

Removal Efficiency.

Figs. 8 to 10 shows the percentage removal for metal/adsorbent systems identified by this study as potential for biosorptive investigations. Removal of Chromium ions up to 87% can be achieved using *Cystoseira Myrica* can reach to about 70% if contact time extend to seven hours using. Depending on the type of reactor/contacting mode which will be applied (subjected to further investigations), these systems are found to be suitable.

CONCLUSION AND SIGNIFICANCE

The uptake of metals is rapid in the first minutes, followed by a slow uptake in after a few hours, reaching to an equilibrium point beyond which the rate of desorption is greater than adsorption. These findings are similar to those obtained for other biosorption systems using immobilised biomass [2] and add to the speculation that the initial biosorptive stage follows second order kinetics.

Metal uptake increases with contact time. Further experiments need to be done to optimize PH, temperature and optimum contact mode. This may lead to pilot plant design of equipment for metal removal from wastewaters containing metals of interest. As these results are only preliminary, a detail study of the adsorbents selected and a wider range of optimization needs to be done. From the preliminary results it is concluded two types of biomass has been identified which has great potential for biosorption in the native form, namely *Cystoseira Myrica* and *Sargassum Polycystum.*

Advantages of using Biomass in Africa is obvious since they are abundant available and are not yet exploited in any way. In the second stage of our research, also, we will look on the possibility of regenerating the biomass for re-use or other means of depositing the used biomass.

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