Developing Countries . . . Environment . . . Arid Lands . . . Natural Resources

Mapping . . . Sahel . . . Archaeology . . . Irrigation . . . Information . . . Transhumance . . . Energy

Southwest Asia . . . Wind Power . . . Remote Sensing . . . Africa . . . Watersheds . . . United Nations . . . AID

ARID LANDS NEWSLETTER

No. 9, December, 1978

UNIVERSITY OF ARIZONA
Tucson, Arizona 85721, USA

Geothermal . . . ALIS . . . Desertification . . . Economic Plants . . . Research

ARID LANDS NEWSLETTER*

No. 9, December, 1978

Editor: Patricia Paylore, Assistant Director (International), Office of Arid Land Studies, 845 North Park Avenue, University of Arizona, Tucson, Arizona 85719, USA.

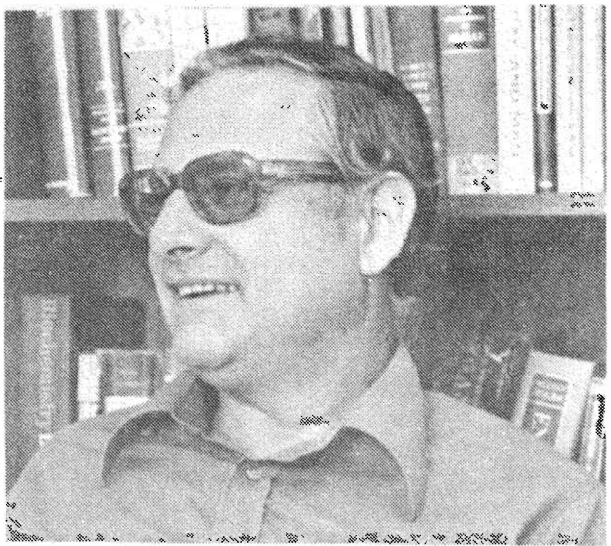
Distributed worldwide without charge. Address correspondence relating to contents, or requests for future mailing, to the Editor.

*Originally issued (No. 1, March 1975) as Arid/Semi-Arid Natural Resources Program Newsletter.

ALGAE - AN ALTERNATIVE SOURCE OF PROTEIN AND BIOMASS FOR ARID ZONES

by

Amos Richmond and Avigad Vonshak*



Amos Richmond

Much progress has been made in recent years in closing the gap between increasing population growth and a demand for a better diet on the one hand, and the world food production on the other. Most of the progress, however, has taken place in the developed, humid countries, where the supply of food is usually not pressing. The food prospect for the developing, mostly arid countries seems poor, for the collective produce of today's conventional agriculture is insufficient to feed the present world population of about four billion people, of which perhaps one-eighth is malnourished.

Added to this grim prospect is the fact that the energy costs of abundant harvests in those areas of the world where such are still possible, together with marketing and distribution costs, serve to hinder the possibility that one part of the world can help feed the other. Nor do established patterns of political and economic dominance tend to contribute to a solution to the dilemma of an equitable distribution of the world's food.

A report of the Advisory Committee on International Action to Avert an Impending Protein Crisis pointed out that the marked difference in *per capita* food production between the developed and the developing countries is bound to increase because death rates are falling, birth rates remain high and crop yields are still low in the developing countries. Moreover, for a substantial part of the present population in the developing countries, the protein-calorie balance of the diet is inadequate so that the gap between the nutritional requirements and the actual consumption of protein is widening.

Algae promise important advantages in providing various products of value to human life. These aquatic plants, which range in size from large oceanic species of over 100 feet long, down to microscopic unicellular forms, can be grown in a continuous culture, providing maximal annual production of biomass per unit area, limited only by solar irradiation. The algal cell contains relatively little purely structural material and most of its body may have nutritious or other economic value. Meeting the CO_2 requirements of algal cultures is relatively simple compared with field crops, because this gas may be readily passed into the growth medium. Some algae can fix atmospheric nitrogen while others thrive on brackish or sea water, thereby providing a key for the production of biomass in many arid zones.

Arid and desert areas offer important advantages for the cultivation of algae. Significantly, these advantages are usually those conditions which impose severe limitations on conventional agriculture:

1. Saline water: Saline aquifers have been located in many desert areas all over the world. For example, the saline aquifers of the Negev in Israel, which vary in salinity from 2500 to 6000 ppm TDS (total dissolved solid) could supply 30 million cubic meters annually with no depletion, and up to three times that amount with only minor depletion. In addition to brackish water, sea water should be considered for desert algae culture, possibly becoming an important source of water for bioproduction of various useful products.
2. Temperature: Summer daytime temperatures in many desert areas typically approach 40° to 45°C, pond temperature remaining a few degrees cooler. Algal growth increases exponentially with temperature until the optimal temperature which for many algal species is ca. 35°C is reached. Thus, normal day temperatures for the hot deserts, which would subject many conventional plant species to severe stress, are in a range for maximal algal production.
3. Availability of large amounts of solar radiation: Both because of the latitudes in which they generally lie and the characteristic absence of cloud cover, the average annual levels of solar radiation are considerably higher in the hot desert regions than in other areas of the world. These high radiation levels hold two advantages for algae cultivation. First, the amount of radiation available for photosynthesis is a more important parameter in determining the rate of growth for algae than it is in conventional agriculture where water, soil nutrients and CO_2 are usually the major limiting factors for production. Second, the high radiation levels open up the possibility of using solar energy to process the harvested algae.
4. Availability of large tracts of empty land; For maximal absorption of solar irradiation, algae cultivation will have to be carried out in shallow ponds, requiring large flat stretches of vacant land. These are abundant in desert areas.

Ben Gurion University of the Negev, The Institute for Desert Research, Department of Biology, Sede Boqer, Israel

NUTRITIONAL POTENTIAL OF ALGAE

The food potential of certain microscopic algae has been fairly intensively studied in the past few years. The blue-green alga, *Spirulina* belonging to the family *Oscillatoriaceae,* is particularly interesting. Rediscovered by the academic world as recently as 1940, *Spirulina platensis* has been collected from the salty lakes and ponds along the northern shores of Lake Tchad since time immemorial, sun-dried and eaten by the Kanembou people, now numbering more than 80,000 persons (Fox, n.d.). *Spirulina geitleri* was collected and prepared similarly by the Aztec Indians at the time of Cortez' arrival in Mexico. *Spirulina* is an easily harvested multicellular filamentous alga of high digestibility and mild flavour which has been found to contain up to 70% protein of excellent quality as shown in Table 1.

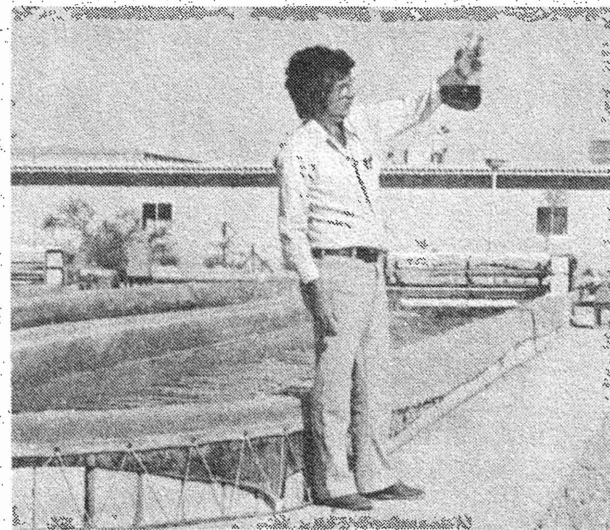
Table 1
Essential amino acid composition of algae-Spirulina- compared to other sources of protein food

Amino Acids	Spirulina sp.	Soybean-Meal	Fish-Meal
Isoleucine	6.0	4.6	5.4
leucine	8.5	7.3	7.7
Phenylalanine	5.0	4.0	5.1
Tyrosine	4.0	2.9	2.7
Threonine	4.6	4.2	4.0
Tryptophan	1.4	1.2	1.5
Valine	6.5	5.2	5.0
Arginine	6.5	5.0	7.7
Histidine	1.8	2.3	2.4
Lysine	4.6	7.0	6.5
Cystine	0.4	1.0	1.4
Methionine	1.4	2.6	1.4

The high content of proteins found in the *Spirulina* makes this product a concentrate by itself, having a significant advantage over conventional vegetable sources of protein which contain a rather low protein concentration.

To improve the amino acid balance of the *Spirulina* protein, additional sulphur-bearing amino acids could be added. This is easily done by including the gluten of wheat or barley in the diet and in fact both the Kanembou and the Aztecs used *Spirulina* with whole grain cereals. A reasonable large-scale goal of only 20 g per m per day would yield 50,000 Kg of protein per hectare anually, compared with beef cattle which averages less than 100 Kg of protein per hectare year (Bhattacharjee, 1970).

The nutritive value of *Spirulina* is amplified in that it has a relatively low percentage of nucleic acids (4%), as compared with the high content of nucleic acid in bacterial protein. The mucoproteic membranes that separate the cells are easy to digest, unlike the cellulose cell wall found in many other nutritional algae; it is completely non-toxic, its lipids made up



Vonshak near one of the experimental ponds

of unsaturated fatty acids that do not form cholesterol, perhaps making the *Spirulina* an interesting food item for patients with coronary illness and obesity, as was suggested by Durand-Chastell (1976). Furthermore, the presence of linolenic acid indispensible for fish feeding, gives it a great advantage for pisciculture.

Similarly, preliminary conclusions of the Carp and Tilapia growth experiments in Dortmund (Pabst, 1975) revealed that unicellular green algae were well accepted by fish, up to 12 % of the feed of Carp and up to 40 % of the feed of Tilapia. In tank experiments unicellular algae could replace 60% of fish meal or part of the soybean meal of the feed of carp without ill affects on their growth.

SOME BIOLOGICAL ASPECTS

A preliminary question that we tackled was to what extent was it possible to maintain a unialgal, continuous culture of *Spirulina platensis* out-of-doors. For this purpose, 1 m^2 ponds of *Spirulina* were maintained as long as possible throughout the summer, cell density being kept constant by continuously filtering excess biomass. The effluent was returned to the pond and the volume of the medium kept constant by daily addition of tap water. CO_2 was added to maintain the pH at 9.5 to 9.8 and the nutrients level was maintained by analyzing thrice weekly the PO_4 and NO_3, adding complementary amounts of the entire mineral make-up when supplementing these nutrients to the medium. Results clearly indicate that as long as temperatures in the pond did not decline below 20°C, *Spirulina* culture could be kept essentially clean of other biological species. The number of bacterial cells did not increase above 5 x 10 per ml. Analysis of the daily specific growth rate could not reveal any signs of self-limitation in the pond throughout its continuous operation from April to October.

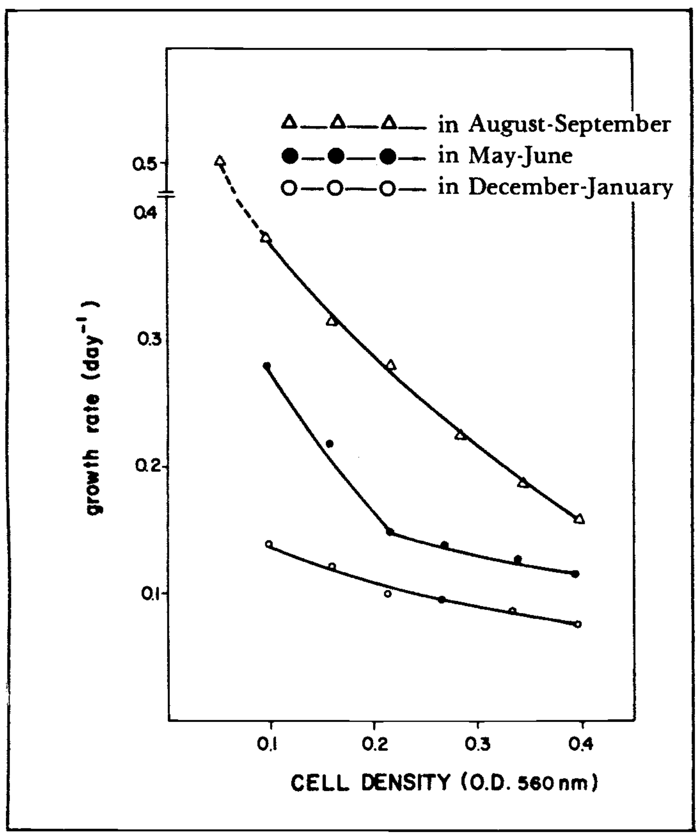
The effect of temperature:

The algal species which today are considered most suitable candidates for commercial production are warm-water species, thus the effect of temperature on the performance of outdoor cultures is of prime importance.

From the beginning of November on, a sharp decline in the growth rate of *Spirulina* was observed. Was this a result of the low night temperature exposing the algae to a cold temperature shock, or was it only due to the declining day temperature? To examine this, night temperature was artificially maintained at 10° thus preventing the decline to 2°-6°C which would naturally occur and, in another pond, day temperature was raised to 25°C but no heating was supplied during the night. Results indicate that preventing the night decrease in temperature below 10° had no effect, while raising day temperature to 25°C resulted in an output rate typical to that obtained in the early fall, before the winter decline in temperature commenced.

When light was the main limiting factor for output rate, a close relationship existed between the specific growth rate (μ) of the culture and its cell concentration (x). However, since μ is substantially modified by temperature, this relationship varied greatly throughout the year. The following figure delineates the effect of x on μ throughout the seasons in the Beer Sheva-Sede Boqer regions, reflecting the complexity of optimizing outdoor algal biomass production. Clearly, the more severe the temperature limitation on μ, the smaller the dependence of μ on x, becoming hardly visible in the mid-winter when the specific growth rate is much smaller compared to its summer peak. (Fig. 1).

Fig. 1.
The effect of cell density on specific growth rate at different seasons



Light as a limiting factor in outdoor *Spirulina* culture:

Due to self-shading, the significant parameter in studying the effect of illumination on the culture is the quantity of light for each algal cell. Outdoors, this paramter is affected by three factors: 1) light intensity, 2) areal density of the culture, and 3) the dark/light cycle to which an average single cell in the culture is exposed, as affected by the extent of turbulence and depth of the medium.

The distribution of incident light through the depth of the pond in different cell concentrations may serve as an indication for the availability of light to the single cell and the light/dark cycle it is exposed to.

Our measurements show that even when cell concentration is very low e.g. 200 mg/1, solar irradiation does not penetrate even to half the pond depth. When cell concentration is maintained at its optimal for maximal output, light penetrates only a few cms. Thus at ca. 500 mg/1 the percentage distribution of incident light is 47, 18 and 2 for pond depths of 1, 2 and 5 cms respectively. When this cell concentration is doubled, percent distribution of incident light is 35 and 3, for a depth of 1 and 3 cms respectively. (These figures were observed in 15 cm deep ponds when 100 percent incident light equals 2.300 micro-einsteins $.m^{-2}$ $.sec^{-1}$).

Since the net output of biomass is a product of both cell density and the specific growth rate, and since these parameters are negatively and essentially linearly related, it is clear that maximal output may be achieved at some optimal cell density, when the system is only light limited. This is shown in Fig. 2.

As evident from this figure, the output rate is decisively affected by the extent of turbulence in the pond. Our interpretation of this marked effect is that it sets a more favourable light/dark cycle for the single cell in the culture. Hence the increase in growth rate that turbulence affects shown in Fig. 3.

It seems evident that greater turbulence decreases each period of darkness in every dark/light cycle that each cell undergoes. Also, when irradiation is very high, e.g. > 100 klux, *Spirulina* filaments placed in the very upper layer of the pond may suffer from over-exposure to irradiance. Intense stirring would decrease the duration of stay in the over-exposed upper layer.

Support for our theses that equates greater turbulence with improved light regimen for the photo-autotrophic cell is that when stirring is enhanced, peak output of biomass is shifted, being obtained at a higher cell density. (Fig. 2).

Optimization of mineral nutrition is important, particularly in *Spirulina* medium made in water rich in Ca^{++} and Mg^{++}. Phosphate, carbonate and heavy metal precipitation which ensues in such water, increases the cost of mineral nutrition, creates harmful nutritional imbalance and deficiencies and increases the turbidity of the medium. Thus, we put special effort into determining minimal concentrations of the major elements that can be maintained in the ponds before the output rate is affected. Our experiments so far, have shown

Fig. 2.
Output rate as affected by cell density and turbulence

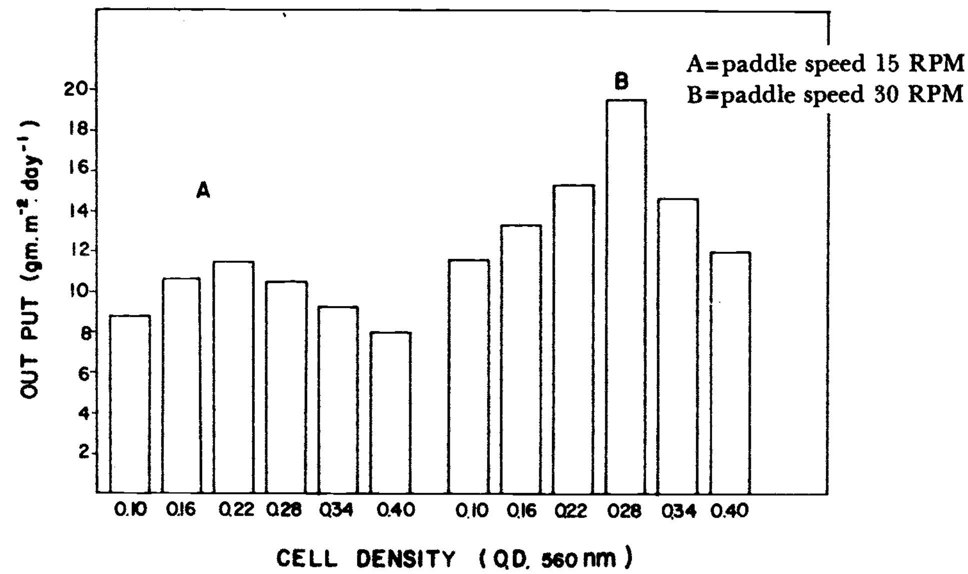
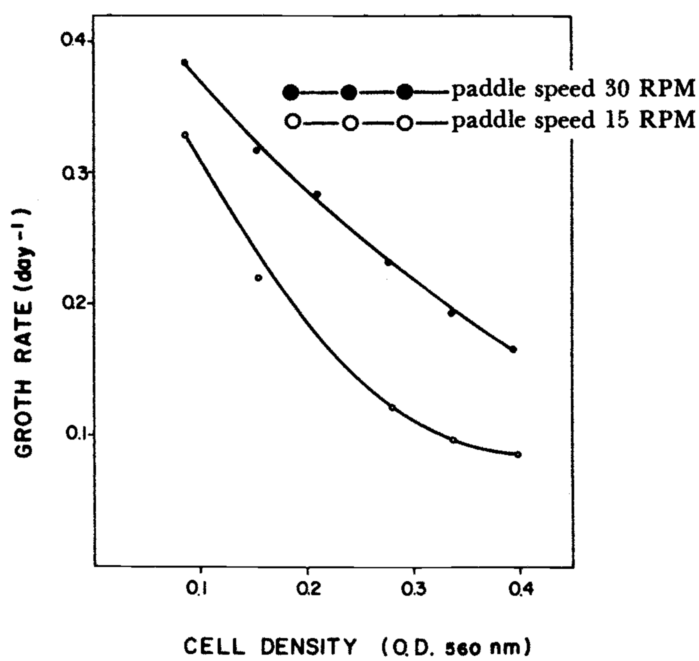


Fig. 3.
The influence of turbulence on the specific growth rate at various cell densities



that phosphates can be maintained at approximately 90 ppm and nitrates at 120 ppm. However, there is good evidence that these concentrations could be much reduced, if feeding will be applied continuously.

In order to follow up the relative performance of the algal culture, a data acquisition system was developed. It yields an analysis of data obtained the year around, showing the relationship between O_2 and good as well as poor performance in the culture. Some data are shown in Fig. 4.

On the left, light is the limiting factor, i.e. the rise in irradiation is closely followed by the increase in O_2. On the right, temperature is the limiting factor which is reflected in the parallel existing between the increase in temperature and O_2. The effects of the intensity of solar irradiance and temperature on pond oxygen is shown in Table 2.

All figures are based on data recorded hourly throughout the year. Each figure represents an average of recordings, 10 percent of which were deleted from both extremes. Most figures shown represent averages of many scores of observations, all of which were taken until 1 p.m. on each day, when pond oxygen was usually on the increase. It is worth noting that the highest pond oxygen was recorded at the highest temperature and irradiation.

Fig. 4.
Typical relations between O_2, temperature and light intensity

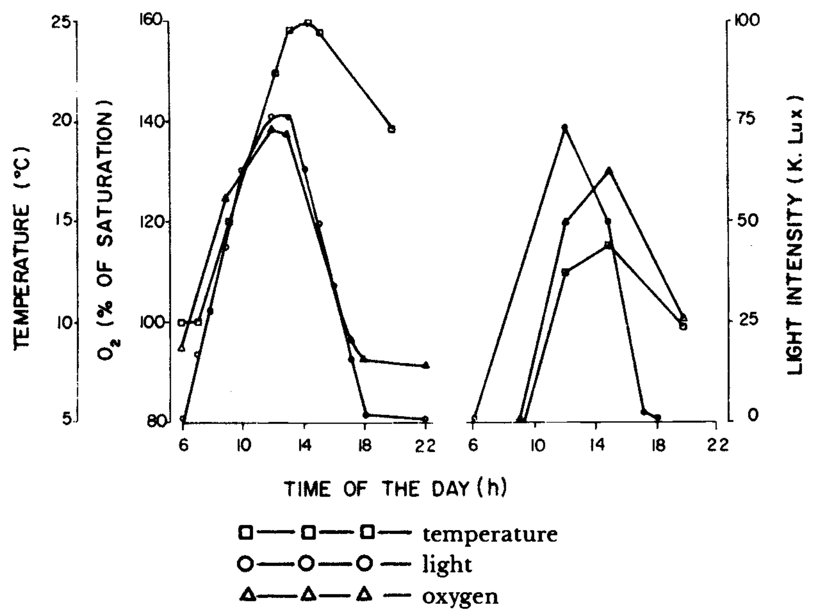


Table 2
Effects of the intensity of solar irradiance and temperature on pond oxygen

Temperature (°C)	Pond oxygen (percent saturation) at irradiance (Klux)					
	0-5	5-20	20-40	40-60	60-80	81-100
0-6	71					
6-12	87	96	109	115	145	
12-18	88	101	113	122	140	157
18-24	94	108	120	131	142	181
25-30	107		135	125	155	208
30-36						

TECHNOLOGICAL ASPECTS

Three major technical aspects are involved in developing an economic system for mass cultivation of algae. The first relates to pond construction, its shape, depth, type of lining and the system of mixing the algae-laden water; the second concerns separating the algal mass from the medium; and the third relates to a suitable method for dehydration of the algal mass to facilitate product distribution and storage. A satisfactory solution of these aspects is essential before large-scale algal cultivation can be pursued economically.

Pond construction

A simple and relatively inexpensive pond construction is suggested by using equipment and techniques adapted from surface irrigation, to construct channels 2.0 to 10.0 m wide and 0.20 m deep. One idea is to line the channels with black plastic sheeting, 0.25 mm thick and to extend them 50 to 300 m, running back and forth, making pond units of 5,000 to 10,000 m^2. The channels may be dug with a slight incline in the direction of flow, assuring a flow of approximately 20 cm min^{-1} . This should create sufficient turbulence for mixing the algae adequately, an essential for the optimal irradiation of each cell in the culture. At the end point of this channel maze, the algal medium will be lifted some 1.0 or 2.0 m, returning the algal medium to the high point. A less expensive and perhaps just as suitable method of construction involves unlined channels with stirring being provided by paddle wheels.

Separation of the algal mass from the medium

Harvesting the algal biomass requires the separation of the algal cells from the aqueous medium. Various methods are possible for this, with the size of the algae to be separated governing the choice. In general, harvesting may be attained by:

- applying gravitational force through centrifugation
- flotation of the algal mass by generating a fine stream of air bubbles through the medium. The small bubbles absorb on the cells' surfaces and increase their buoyance which results in flotation
- separation accomplished by introducing chemicals into the medium which induce the single cells to flocculate. A commonly used flocculant is aluminium sulphate which facilitates separation by flotation, the foamed biomass becoming easily filtered. The algal powder obtained after dehydration contains about 20 percent aluminium, thus requiring a further acid wash. Edible flocculants are also available, and if they become sufficiently cheap, the production of algal single cell biomass for food or feed will become more feasible.
- causing the algae to sediment, either by letting them settle on suitable membranes or inducing sedimentation by the addition of proper agents. The sedimented algal mass ma then be collected by various means
- filtration appears to be the obvious choice for the first stage of separation from the medium. The type of filter and the process depend on the algae to be separated and on the production rates
- small micro-algae, such as *Scenedesmus* or *Chorella* with a size of a few microns pose great problems in today's technology, due to speedy clogging of the filter. J.D. Dodd and J.L. Anderson (Caldwell Connel Engineers, Melbourne, 1975), however, have devised a micro-algae harvester based on a paper pre-coated belt running over a filtration drum. Today, only the filamentous *Spirulina* is readily filtered on a 300-mesh commercial filter, but precautions must be taken to avoid physical damage to the delicate cells and filaments so as to prevent leakage of cellular matter.

Dehydration of the algal mass

Dehydration forms a problem of major economic importance. The systems of dehydration differ both in the extent of capita investment and energy requirements and have a marked effect on the biological value and taste of the produce, particularly with regard to the green algae which have a cellulose encasement. In Dortmund, Pabst and associates (1975) have shown that dehydrating algal mass with a fine layer drum dryer yields an excellent product. In that system an algal suspension of 6-8 percent obtained by centrifugation is injected on a rotating, steam heated drum, heating the algal cells for a few seconds and the dehydration which ensues causes the cellulose encasement of the green algae to pop open, thereby *greatly increasing the edibility and biological value of the powdered product*. According to Soeder and Mohn (1975), 15.7 Kcal are needed for the evaporation of 18.2 kgms water that is removed to obtain 1 kg of dry powder with a water content of 4 percent. This energy input is in addition to the 1.4 kwh which is needed to run the machine itself. It is quite clear that energy expenditure may be saved if other methods of dehydration were tested, such as subjecting the filtered or flocculated algal mass to a steam treatment followed by vacuum filtration and concluding the dehydration is a rotary kiln (Berk, personal communication). Soeder and Mohn (Ibid.) suggested that dehydration may be successfully achieved by mixing the algae with dry additives such as straw, sugar beet pulp, meal powder or grains, and thereafter pressing the mixture by extrusion, producing pellets instead of powder. Although direct dehydration of algal biomass in the sun is possible, it is not recommended as it is harmful to quality and requires large drying areas. Nevertheless, a possibility which has so far not been explored but may well be uneconomic is the harnessing of solar energy to create a source of heat for dehydration of the biomass.

OTHER COMMERCIAL USAGES FOR ALGAE:

Protein is only one of the several products which can be commercially derived from algae. There are various chemicals which are already extracted from algae or which are envisioned to become commercial products.

Today three major algae products are extracted from marine algae (Round, 1973). These include alginic acid derivatives, carrageein, and agar:

- •••Alginic acid is extracted primarily from laminaria and microcystis. The alginates are used for various purposes such as in the food industry, in cosmetics, and in the textile and rubber industries as well. They are also used as emulsifiers and gelling agents.
- •••Carrageenin, like the alginates, is a cell wall polysaccharide complex which gels in the presence of potassium and is used like alginates to stabilize emulsions and suspend solids in foods, as well as in the textile, pharmaceutical, leather, and brewing industries.
- •••Agar is a name used for a dried or gel-like non-nitrogenous extract from rhodophycean algae. It is used as a medium in the cultures of bacteria, fungi, and algae, and also in numerous products.

To a much lesser extent, marine algae are used for pharmaceutical purposes. Yet there is a growing interest today in finding a biologically active compound derived from marine organisms. There have been reports on the contents of special compounds in red and brown algae such as bromoacetylenes and bromobenzine derivatives, as well as steroids. In China, a drug of some importance as an antihelmitic has been described, and a product from the sea-weed laminaria was reported to have anti-hypertensive activity. Finally, there have been numerous reports of some anti-bacterial products from various algae.

Recently much thought has been given to the possibility of using algae for the production of biofuels. Hydrogen and methane particularly have been discussed. It seems, however, that fuels are not yet sufficiently expensive to warrant their production from algae for a long time to come. Today the energy used to produce and harvest them may be greater than the energy obtained from them. Thus a more promising possibility lies in products such as glycerol and other alcohols, acids and starches. In various parts of the world, preliminary experiments are being conducted to test the economic feasibility of deriving these products from algae. Another possibility is in biochemicals and various other natural products even though needed in much smaller quantities. These include pigments, vitamins, special lipids, steroids and other such products and may serve as by-products.

Finally, the human health market may become an important outlet for algae. In Japan, powder made out of an algae named *Chlorella* is regarded as having remarkable health properties. It is also claimed that algal powder possesses various therapeutic qualities for healing gastric ulcers, various kinds of wounds, liver necrosis, regulation of blood pressure, or prevention of decrease in leucocytes.

In summary, we believe that a consistent effort towards optimization of algal biomass production, harvesting and product processing, as well as genetic engineering and basic research to better comprehend relevant bio-synthetic pathways, will yield, step by step, biotechnologies of significant economic importance. This would seem particularly useful in arid lands in which populations are malnourished and in need of organic raw materials, yet cultivation of plants by conventional methods is severely handicapped. In these areas algaculture in saline water enjoys distinct relative advantages.

REFERENCES

Berk, Professor Z., Technion, Haifa, Israel, Personal communication

Bhattacharjee, J.K. (1970) Micro-organisms as potential sources of food. Advances in Applied Microbiology 13:139-161.

Caldwell Connel Engineers, Melbourne (1975) Field testing an algae harvesting process. Report.
Australia Department of the Environment, Bureau of Environmental Studies, Canberra

Durant-Chastell and Sanches, Sosa Tecoco, S.A., Mexico (1976) FAO-Technical Conference on Aquaculture, Kyoto, May 26-June 2.

Fox, R.D. (n.d.) A solar energized system for algalculture. Laboratoire de la Roquette, 34st Bauzille de Putois, France

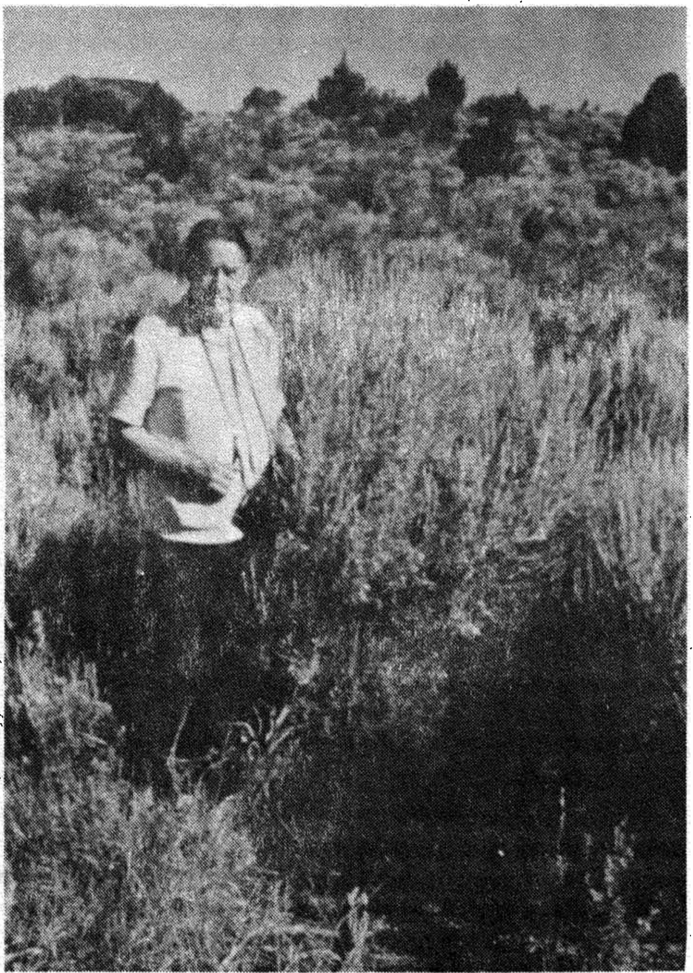
Pabst, W. (1975) Die Mossenkulture von Mikroalgen. Kraftfutter 58 (2).

Round, F.E. (1973) The biology of the algae. Edward Arnold, London.

Soeder, J./Mohn, H. (1975) Technologische Aspecte de Mikroalgenkulture. Symposium Mikrobielle Proteingwinnung.

MIKHAIL PLATONOVICH PETROV

October 9, 1906–June 6, 1978



Michail Platonovich Petrov

The death of Academician Petrov in Leningrad on June 6, 1978, has saddened his many friends and desert colleagues throughout the world. This Russian botanist and geographer, a graduate of Leningrad University (1930), was on the staff of the All-Union Plant Institute from 1928 through 1941 during which time he became Director of the Repetek Sand Station, Kara-Kum (1930-1934) and following that assignment Director of the Turkmen Experiment Station in Kopet-Dag (1937-1941). During World War II Petrov was Director of the Biology Institute of the Turkmen branch of the USSR Academy of Sciences, later Department Chairman (1944-1946), and Vice President of the Agricultural Sciences Section (1951-1957). In 1947 he began a long association with Leningrad State University from which base in the Geography Department he initiated the series of publications on the Chinese and Central Asian deserts which are still in many ways the most up-to-date information we have on these relatively unknown areas.

An indefatigable research scientist in the true tradition, Petrov brought his professional life to a close with his recent retirement, his worldwide reputation as a specialist in the plant life and geographical problems of arid and semiarid regions one which is not soon to be challenged.

Here at Arizona, we were privileged to have had visits from him on several occasions, being remembered by:

Director Emeritus *William G. McGinnies* of the Office of Arid Lands Studies who remembers him last when attending the XII International Botanical Congress in Leningrad where Petrov had organized a program on desert ecology which he asked Dr. McGinnies to chair. The accompanying informal snapshot is one taken in 1971 by Dr. McGinnies on a field trip to Ephraim, Utah, where he and Petrov were attending a shrub conference in Logan...

Terah L. Smiley, Professor of Geosciences, who remembers him best as he presided over one of the plenary sessions of the 1969 AAAS Committee on Arid Lands-University of Arizona joint conference on Arid Lands in A Changing World. Smiley recalled Petrov's willingness to talk to anyone at any time, and the generous way in which he shared his knowledge and experience with all of us, but reminding me, too, that he was first and always a scientist...

Andrew W. Wilson, Professor of Geography, who last met Petrov in the summer of 1976 when he attended the Moscow meeting of the International Geographical Union. His amusing story of an exchange of gifts during the Ashkhabad pre-conference meeting of the IGU's Working Group on Desertification shows us that Petrov was not without a sly sense of humor, making him more than ever, as Smiley remembers, a very human person.

So all of us are agreed that he was indeed a man of the world, serious, dedicated, knowledgeable, friendly, willing to share. All around the desert world, from Sinkiang to the Great Basin, he will be missed.

As a small contribution to the occasion, we are displaying here citations of several publications relating to his specialities of sand dune research and desertification, as well as his more synoptic works on deserts generally.

Petrov, M.P.

1977 Problems of management and conservation of deserts and desertification control (translated title). Institute of Scientific and Technological Information, Moscow. 148 p.

1973 Deserts of the world. Translated from the Russian edition (Leningrad). Halsted (Wiley), N.Y., and Israel Program for Scientific Translations, Jerusalem (1977). 448 p. maps.

1971 Sand stabilization methods in arid lands: Protection of agricultural and settlement areas. *In* W.G. McGinnies, B.J. Goldman, and P. Paylore, eds., Food, Fiber and the Arid Lands, p. 355-368. University of Arizona Press, Tucson. 437 p.

1970 Deserts of Asia. *In* H.E. Dregne, ed., Arid Lands in Transition, p. 279-302. American Association for the Advancement of Science, Washington, D.C., Publication 90.

1969 Utilization of aerial photography for the geographic study of the deserts of Central Asia. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Special Report 175. 124 p. [Available NTIS as AD-693 147].

1966 Pustyni tsentral noy Azii (Deserts of central Asia). Nauka, Moscow/Leningrad. 2v. (Translation available NTIS as JPRS 39145, 357 p.; JPRS 42772, 420 p.)

1967 A review of literature on the reclamation of desert and semi-desert sands in the USSR for 1965 (translated title).

1966 Akademiia nauk Turkmenskoi SSR, Ashkhabad, Izvestiya, seriya Biologicheskikh nauk 6:79-87.

966 The productivity of some shrubs of the south-eastern part of the Kara-Kumy desert (translated title). Botanicheskii Zhurnal 51(10):1519-1521.

966 Eshche raz ob usykhanii Azii (On the desiccation of Asia). Vesesoyuznoyo geographicheskoyo obshchestvo, Izvestiya 98(3):205-211.

1962 Types des deserts de l'Asie centrale. Annales de Geographie 71:131155.

1962 On grain size and mineral composition of sands in east central Asian deserts (translated title). Leningradskogo Universiteta, Vestnik 12, seriya Geologii i Geografi 2:65-

1961 The mineralogical and granulometric composition of the eolian sands of the Ordos, the eastern Atashau and the middle Yellow River (translated title). Leningradskogo Universiteta, Vestnik 6, seriya Geologii i Geografi 1.

1960 Geograficheskie isseledovaniya v pustynyakh Tsentral'noi Azii. Leningradskogo Universiteta, Vesnik, seriya Geologii i Geografii 24:118-130. (Issued in translation under the title: Geographic explorations in the deserts of Central Asia. Available JPRS 9221 (1961, 31 p.)

1959 Rastitle'nost'pustyn'Tsental' noi Azii (Ordos, Alashan, 'Beishan') i osobennosti ee raspredeleniya. Botanicheskii Zhurnal 44(10):1387-1408.

1959 Botanicheskie issledovaniya v severnoi chasti Tsentral'nogo Kitaya (Botanical investigations in the northern part of central China). Botanicheskii Zhurnal 44(8):1198-1212.

1948 Le relief des barkhanes des deserts et les rapports de sa genese avec la theorie. Akademiia Nauk SSUR, Institut Geografi, Vestnik 39:184-

1939 Ecology of desert plant culture (translated title). Voprosy Ekologii i Biotsenologii 5/6:3-39.

1936 On the ecology of saltmarshy and sandy saksauls (translated title). Voporosy Ekologii i Biotsenologii 3:3-46.

1935 Problemy rastenievod (Ecology of the Repetek Sand Desert Preserve in southern Karakum). Osvoen. Pust. 4:9-66.

1933 Kornevye sistemy rastenii peschanoi pustyni Karakumy, ikh raspredelenie i vzaimootnosheniia v sviazi s ekologicheskimi usloviiami (Root systems of plants in the Kara-Kum desert, their distribution and interrelation in connection with ecological conditions). Trudy po Prikladnoi Botanike, Genetike i Selektsii, seriia 1, 1:113-208.

??? ANYBODY WANT ???

Listed here are copies of various publications which are duplicates of the Arid Lands Information Center's collection. They are available without cost, except for shipping, to any of *Arid Lands Newsletter's* readers. Foreign requests should indicate whether materials selected are to be shipped surface mail or air mail parcel post.

Arid Lands Research Newsletter (AAAS Committee on Desert and Arid Zones Research):
- no. 8, November 27, 1961
- nos. 11-24, inclusive, April 10, 1963-July 1967
- nos. 26-35, inclusive, January 1968-October 1970
- nos. 37-41, inclusive, January 1971-December 1972 (no more published

Arid Zone (UNESCO):
- nos. 2-7, inclusive, December 1958-March 1960
- nos. 9-26, inclusive, September 1960-December 1964

Arid Zone Newsletter (CSIRO, Australia):
- 1963, 1965-1970 inclusive, 1972-1977 inclusive

Desert Research Institute Reno, Nevada:
- Technical Report ser. H-W, Hydrology and Water Resources publication 5 (1967): An engineering-economic analysis of systems utilizing aquifer storage for the irrigation of parks and golf courses with reclaimed waste-water. 123 p.

International Insitute for Land Reclamation and Improvement, Wageningen, The Netherlands:
- Bibliography #6 (1967): Annotated bibliography on reclamation and improvement of saline and sodic soils (1966-1960).
- Publication #12 (1963): Applications of soil survey in land development in Europe.
- #13 (1965): Soil ripening and soil classification.
- #14 (1968): Irrigation requirements for double cropping of lowland rice in Malaya.
- Annual Report 1967.

International Journal of Biometerology
- Scattered issues between v. 5 (1961) and v. 15 (1971)
- International Society of Biometerology, 3d International Biometerological Congress, Pau, 1963. Program. Participants. Abstracts.
- ------ 4th, Rutgers University, 1966. Program.

National Academy of Sciences, Washington, D.C.
- More water for arid lands: Promising technologies and research opportunities. 1974. 153 p. (Reproduced copy [PB-239 472]. paper

U.S. Army Engineer Topographic Laboratories:
- Technical Report #ETL-TR-72-5: A contribution to the philosophy of climatic design limits for army materiel — extreme hot-desert conditions. June 1972. 60 p.

U.S. Army Natick Laboratories:
- Technical Report #70-39-ES: A comparison of annual rainfall probabilities in Thailand and the Canal Zone vicinity. March 1970. 53 p.
- Technical Report #70-68-ES: Seasonal contrasts in the eastern Mojave Desert. August 1970. 44 p.

U.S. Office of Water Resources Research, Water Resources Information Center, Washington D.C.

Bibliographies:
- Detergents in water. December 1971. 460 p.
- Dieldrin in water. January 1972. 144 p.
- Magnesium in water. July 1971. 152 p.
- Manganese in water. July 1971. 127 p.
- Mercury in water. January 1972. 294 p.
- PCB in water. (1973?) 144 p.
- Strontium in water. June 1971. 80 p.
- Zinc in water. July 1971. 138 p.

Western State Conference on Water Information Dissemination:
- Proceedings of a conference held June 8, 1973, in Phoenix, Arizona. 98 p.

World Meterological Organization, Geneva:
- World Weather Watch: The plan and implementation programme, May 1967. 56 p.
- ------ First status report on implementation. July 1968. v.p.

ARID LANDS NEWSLETTER NEEDS

unwanted copies of No. 2 (July 1975) and No. 4 (October 1976).

Anyone who no longer has need for his copy of either of these two issues will be doing *Arid Lands Newsletter* a great favor by returning them to the Editor. They are completely out-of-print, but requests continue to come in from those who wish to retain complete files.

THANK YOU!

... AND NOT A DROP TO DRINK

I am sitting here in the warm sand at Rachel Carson's *Edge of the Sea,* far from my desert home. It is true I am listening on my little transistor radio (ah, technology!) to Vladimir Horowitz playing the Third Rachmaninoff with Zubin Mehta and the New York Philharmonic, several thousand miles away, but actually I am thinking about water, fighting a temptation — because there is so much of it before me, virtually limitless, all the way to that clear dark blue horizon, and beyond — a temptation to think that this is forever. In my euphoria, I think what need to worry about polluted water, brackish water, irrigation water, surface water, saline water, underground water, or no water.

There is much water on Earth. Besides all this sea water, burnished in the late afternoon sun, a part of all ninety-seven percent of Earth's water that is salty, there are great rivers, sparkling lakes, running crystal streams, artesian wells, brimming reservoirs, water holding in great glaciers, and that three-fourths of Earth's three percent total freshwater locked in the formidable ice shelves of Antarctica.

Water?

Yes, there does seem to be a lack of it from time to time, in Iowa and Texas and Israel and Peru and Arizona (even though we have an astonishing number of boat owners there), and, now that I think lazily of it, in parts of every other continent on Earth.

Water, that element from which all life comes, that common substance without which life cannot be sustained, that unfailing source that we take for granted when we turn on the faucet to do our laundry, bathe, water our lawns, wash our cars, fill our swimming pools, flush our sewers, and oh, yes, drink — it is little wonder that thoughtful troubled people worldwide are obsessed with thoughts of water, or no water. For despite that litany of the great rivers and the brimming reservoirs recited above, the problems are urgent, widespread, visible, and for much more important uses than for those swimming pools and car washes.

Item: The great rivers. Let us begin with that one best known to me, the Colorado, that historic stream rising high on the western spine on the Rocky Mountain West that bore John Wesley Powell down through its brilliant cross section of geologic time. All great rivers have lives of their own, though man more and more usurps the definition and distorts the character of those whose assets he covets to exploit. And so it is with my Colorado. It has been dammed and tamed, and its flow diminished. In the days ahead it will be unrecognizable to Powell's inheritors, if indeed it is not already.

Item: Sparkling lakes. The water-short west is dotted with drying lakes, their shorelines receding, their fish gasping in the mud, the oxygen level below what is necessary to keep them alive to satisfy the fishermen who expect to find these lakes plentifully stocked regularly and artificially with hatchery-reared trout (this is "sport"?).

Item: The brimming reservoirs. Lake Mead behind Boulder Dam, Lake Nasser behind the High Aswan Dam, Lake Volta behind the river that bears its name — you name the others. Because evaporation control efforts on large bodies of water, such as Lake Mead with its 550 miles of shoreline, are difficult, expensive, unproved, the total evaporation losses from a string of Colorado River lakes is more than ten percent of the annual flow down river. Total evaporation losses from Arizona's two million acre feet of other surface water is on the order of 95 percent. To losses from evaporation, add into this equation the silting up behind dams, and the expression "brimming" may become just a memory.

Item: Antarctica's icebergs. Happy proponents of the use of what they term this "renewable" resource for water-starved Middle East kingdoms have determined that it is "economically feasible," and in some eyes no further consideration of ecological or environmental uncertainties are to be allowed to introduce any cautionary note. With our high technology, anything is possible, so we invoke the technological imperative: if it can be done, it will be done.

What are the prevailing attitudes that influence decisions relating to the management of water, in Arizona or in the Sahel? Is it not demonstrably true now that the scientific and technical steps we could be taking to bring our water resources into equilibrium with the demands made upon them are on a collision course with economic and political realities? So? we ask irritably, we must be paralyzed? unable to deal with global problems mutually, to create through such a mechanism of understanding not only the imposition of old tried-and-true means of attacking familiar problems but new flexible responses to a world we did indeed made and one to which we owe restitution?

Certainly the world's water problems might be more readily solved if the urgency of the need to do so could overcome the global investments in missiles, nuclear warheads, tanks, grenades, rifles, stockpiled against imaginary enemies.

It is getting dark now, and the tide is coming in. Rachmaninoff has long since faded into silence. I get up stiffly, for the sun's warmth has drained away from me during a long afternoon of contemplation. I gather my beach gear and start home, kicking an empty beer can angrily as I make my way through the sand. But wait:

I go back, laughing a little shamefacedly at myself, pick it up, even though it is not mine, and carry it over ceremoniously and somewhat ostentatiously and toss it in the nearest trash can.

My good deed for the day.

- Patricia Paylore

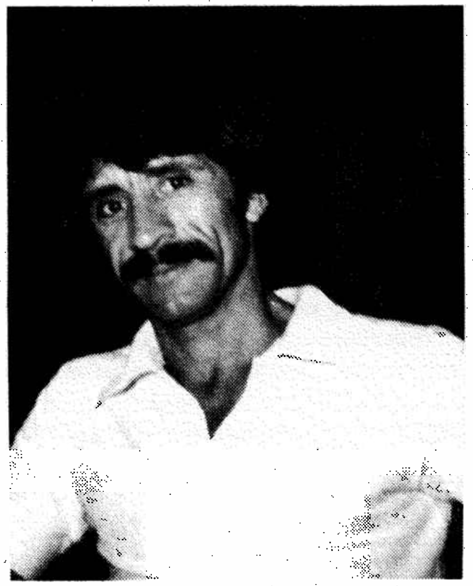
FOREIGN STUDENT PROFILES
VII: Issa Mohammadi

When we were in Graduate School minoring in Philosophy, a hundred years ago more or less, we remember spending a semester comparing Zoroastrianism as exemplified in Nietzsche's *Thus Spake Zarathustra* with that later Persian astronomer-mathematician-poet Omar Kahyyam. But not even the nostalgia of that recollection prepared us for the friendship we have currently established with a modern Persian, Issa Mohammadi, a doctoral candidate in the field of biochemistry-nutrition in the University of Arizona's Graduate College. For now we are looking at Iran as an arid land, studying its environment and resources from this point of view rather than that of that fifth century BC founder of an ancient Iranian religion or his twelfth century countryman who wrote so eloquently of the pleasures of the vine.

Although Mohammadi is a native of Hamadan, the earlist capital of ancient Persia, his family moved to Tehran later, and it was there that the children were schooled in preparation for the college training each is now purusing, one brother at the University of Illinois doing Ph.D. work in nuclear engineering, another at the University of Oklahoma, majoring in architecture. All three are preparing for careers in Iran in their respective fields, hoping in their individual ways to contribute to a modern Iran that will carry on the long and honorable history of this ancient land.

In discussing the climate and geography of Iran, we agreed that its problems with aridity and desertification are typical of extensive areas throughout the Middle East. In Iran itself, about one half the country's more than 636,000 square miles is within the sparsely settled Central Plateau where summer temperatures are extremely high and winters can be bitterly cold. These great salt deserts are among the driest and most barren in the world, with settlements confined to oases and the flanks of small mountain elevations. Having no outward drainage, this region occupies a series of closed basins, with an average annual rainfall of only a few inches — or none. Yet this historic region of Darius and Xerxes and Cyrus the Great has potentially fertile soil, with irrigation boosting agriculture in the mountain valleys, and dams rising to impound runoff from winter-whitened peaks in the great mountain chains that spread a gigantic V over the country.

What do you hope to achieve with such an educational experience as you are undertaking here, we asked him skeptically, playing the devil's advocate. And he answered by reminding me of a growing population, estimated at 35 million currently, and its needs for a new emphasis on better nutrition,



Issa Mohammadi

particularly for those hundreds of thousands who ar abandoning the countryside to flock to what is looked upon as a better life in the big cities but who, once there, find themselves dependent on a life-support system that does not provide opportunities for self help.

Where in the arid world is it not so, we asked gloomily: Cairo, Phoenix, Lima, Algiers, Tijuana, Karachi — you name it.

But with Mohammadi's studies in the biochemistry of native plant resources and soil nutrients, he hopes to help institute educational programs in schools at all levels, to create a better climate for understanding on the part of new generations of those elements of nutrition that make for better health standards. With Iran's cattle-sheep-goat livestock resources, and the country's thriving date-barley-rice-wheat crops, there would seem to be little reason why such a program should not succeed.

We told Mohammadi about our correspondence with Ferdowsi University in Mashhad in the northeastern part of Iran, where we had advised on the establishment of an arid lands research institute, and how we hoped that the concept of extension specialists so common in the land grant colleges of the U.S. might be employed in that particular situation. Tha led us to a discussion of the idea of itinerant teachers wh might move about from oasis to oasis, or in the case of nomadic pastoralists, actually with the tribes and their flocks. It is a model being used in various deserts presently, some successful, some failures. But in an effort to reverse the demographic pattern of rural-to-urban migration, such a notion seems to us to be a feasible one.

Mohammadi believes that mobile medical clinics, as well as purely educational ones, might be a way to introduce the framework for better nutrition, not only among isolated rural areas and small settlements where medical facilities are minimal or non-existent but also among the growing poorly-served urban slums. Variations on this theme might include evening classes for the older population who could then continue the elementary school teaching once the mobile unit had moved on to its next call. Succeeding visits on a rotating schedule could be used to provide supplies, advice and consultation for improvements, and to assess the success of the training program itself. Both of us, however, recognized that cultural habits are difficult to change, and Mohammadi's wish to be a catalyst in this development is why he is determined to prepare himself in the best possible way, with the help of his American-born wife, Judy, also a biochemist by training, and who, incidentally, is an expert in Iranian cookery. And so in this roundabout way, we came back to answering my original question.

Perhaps it could best be summed up, I thought, by Omar himself who expressed the age-old wish to leave behind us a better world than the one we inherited:

Ah Love! could thou and I with Fate conspire
To grasp this sorry scheme of things entire,
Would we not shatter it to bits — and then
Re-mould it nearer to the Heart's Desire?

-Patricia Paylore

QUOTES

...For every 300 cigarettes made from Third World tobacco, a tree is burnt. For every acre of flue-cured Virginia tobacco grown in developing countries, an acre of woodland must go up in smoke. But supplies of wood are limited. In 1977 UNEP warned that shortage of firewood was rapidly becoming the poor man's energy crisis. Firewood is still the overwhelming source of energy for the two billion people who live in the rural villages of Asia, Africa, and Latin America. And in the semiarid regions, the ecological consequences of firewood consumption contribute to desertification. Many of the Third World's tobacco-growing areas lie in dry sandy country, where few other cash crops prosper. That makes it an apparently attractive option to the farmer. Eastern Kenya, for instance, has already been severely denuded by demands for wood, both to fuel the country's cooking fires and to export charcoal to Kuwait and Arabia. But British American Tobacco encourages farmers to grow tobacco there ... The problem is not confined to Africa. In Pakistan tobacco growing has been encouraged in the arid Northwest Frontier Province.[While other solutions are being tried]...for the moment timber will remain the most important fuel for Third World tobacco farmers. That means that tobacco will continue to place heavy demands on the poor man's energy source — and on his environment. In the United States, Britain, and many European countries, every cigarette packet carries a health warning. Perhaps the wording should be changed so it reads:

"Smoking causes cancer of the lung — and of the land."

- *Earthscan,* vol. 1, no. 4, p. 9-10, July 1978.

SOLAR ENERGY, WATER AND INDUSTRIAL SYSTEMS IN ARID LANDS:
Technological Overview

by
Christopher Duffield

Solar energy technology has been undergoing a major revolution, manifested by rapidly accelerating growth, evolution, and diversification, since the 1973/1974 oil crisis awoke the world to fossil fuel mortality. The entire solar energy field is in ferment, displaying aspects of a jungle or a multi-ring circus; solar r & d seems to have elements of near anarchy, with companies large and small joining solar industry in droves, and the state of the art an exploding jumble of products, trade secrets, patents, corporate projects, and backyard inventions. Government r & d programs around the world appear fragmented, their strategies often resulting from personal bias, institutional history, or chance. And though the technical literature appears to be doubling every two or three years, the rate of technology expansion and diversification is already beyond the capacity of existing publication and information systems.

There is clearly an urgent need for new ways of thinking about solar energy technologies, new ways of seeing them, comprehending them, predicting and guiding their impacts and evolution. A unifying viewpoint, a stable intellectual platform is needed from which to observe and manipulate diverse solar technologies large and small.

In the midst of complexity, something simple but significant can be said about the whole solar energy field: all solar technologies, when manifest at macroscale, will form industrial ecosystems ("*Technoecosystems*") which consciously or unconsciously imitate biological ecosystems.

"Technoecosystem" or "industrial ecosystem" refers to large complex industrial systems analogous to (and which usually look like) biological ecosystems. In integrated efficient patterns, technecosystems usually contain:

- ...large human-controlled natural systems (for example, managed bioecosystems and rivers)
- ...storages of energy and materials (water reservoirs, copper stockpiles, etc.)
- ...channels for energy, materials, and information (paths, highways, railroads, pipelines, telephone and power cables, etc.)
- ...numerous small simple modules (hammers, radios, etc.)
- ...many spatially discrete mobile or stationary complex industrial modules (cars, trains, airplanes, ships, houses, factories, powerplants, etc.)

Perhaps the best way, then, to understand solar (or any) technology as a whole is by analogy to biological systems, the only other systems with comparable diversity of form and complexity of organization. This may be the new paradigm we seek , the most powerful single thought framework for comprehending the complex structure and evolution of our industrial civilization, and for guiding it toward its solar energy destiny. The two ecosystems, bio- and techno-, are alike in many aspects of their geometry, organization, and dynamics. The analogy is not just skin deep; it operates at all scales, from molecules to planets, offering comprehensive insights, research and invention ideas, and management strategy concepts.

Solar energy is the trophic base of essentially all biological systems, with solar resources large enough to run all technoecosystems on this planet, and many beyond, for millions if not billions of years.

Technoecology is not just a useful idea framework. It is also an experience, a state of mind, an esthetically, intuitively, and intellectually satisfying way to perceive and appreciate the biological and industrial systems which surround us. Particularly satisfying are its *holistic* and *synergetic* qualities. Rather than examining discrete diverse details of solar technology in fragmented form, as most research does, technoecology gets us up out of the system, pulls us back for a *holistic* unified overview. Details are integrated like threads in a tapestry.

Equally important is the *synergetic* nature of technology: biological and technological concepts and facts, powerful when separate, are more potent still when they are interfaced. For the tuned-in mind, solar technology literature seethes with biological similarities and implications, a synergy so large and powerful that all that can be done presently is to point out the connection between the two worlds.

"In the history of sciences," one writer observes [Jacob, F. (1977) Evolution and Tinkering. Science 196 (4295): 1161-1166], "important advances often come from bridging the gaps" between isolated islands of scientific knowledge, and by recognizing "that two separate observations can be viewed from a new angle and seen to represent nothing but different facets of one phenomenon." Great rewards may await anyone who dares to bridge the gap and explore the full breadth and depth of the bio-techno analogy. Solar energy is a good place to start.

We believe:

... that technoecology is a useful approach for understanding, designing, and managing solar energy powered industrial systems
... that technoecological concepts are applicable over the full ranges of time, size, and sophistication
... that technoecology can help provide a basis for a coherent, comprehensive successful solar energy r & d strategy
... that a solar-based civilization may soon be upon us and that projections, based on technoecological insights, may be made about how it may arrive and what it may be like
... that it is possible, within this technoecological framework, to examine past, present, and possible future interactions of sunlight, water, and technoecosystems in arid lands

A solar energy revolution is brewing in technoecosystems around the world, and it appears to be on the verge of exploding into popular awareness. In many laboratories and factories, scores of solar energy inventions and technologies are being developed, each of which, if perfected and multiplied by millions, could transform desert cultures, global technoecosystems, and the lives of all humanity. In the history of technology, evolutionary spurts have involved development of ways to *use* energy, but never before has there been a time or technology in which so many ways to *capture* energy were opening up and being explored.

The only analogous situations that come to mind are the agricultural revolution, in which men tried and adopted many plants and cultivation systems, and the photosynthetic revolution, in which numerous biochemical and structural means were evolved and selected in primitive organisms. But those revolutions occurred on much large time scales (centuries or millenia, and millions of years, respectively), while the solar energy revolution is occurring in a greatly accelerated time frame of years to decades. Technoecological overview allows us to better appreciate the momentous nature of this revolution, and give us an early sense of what kinds of phenomena to expect and what kinds of actions might be most effective in speeding and smoothing its progress.

This excerpt from Dr. Duffield's larger copyrighted work of the same title, issued as* ***Arid Lands Resource Information Paper* *No. 12* (c1978, 151 p.), *is reprinted here with permission of the author. The whole work is available from the Office of Arid Lands Studies at $10.00, paper.*

DESIGN AND THE DESERT ENVIRONMENT

A new publication just issued from the Office Of Arid Lands Studies, University of Arizona, as Arid Lands Resource Information Paper No. 13, is called:

Design and the Desert Environment: Landscape Architecture in the American Southwest
by James D. Miller. 1978 216p. $12.50.

Landscape architecture (environmental design) in the hot arid southwestern U.S. must respond to the extremes of climate, the distinctive landforms, and the vegetative communities that combine to create unique patterns within the desert landscape. Human comfort is defined and serves as a criterion for the manipulation of microclimates to achieve a relative sense of comfort within a hot arid environment. Methods of solar radiation control, wind control, and conservation of water resources are reviewed. The text is supplemented withmany illustrations and drawings. Over 200 drought-tolerant plant species are listed for use in the desert landscape. Cultural information for each plant is included in a matrix, and many of the plants so described are represented photographically as well. In addition to the references used for the text, a computerized bibliography, including abstracts, of related topics is added in the appendix.

SETTLING THE DESERTS, the First Ben-Gurion Memorial Symposium in honor of the dedication of the Institute for Desert Research, Sede Boqer, Israel, December 4-8, 1978.

Sessions on farming the desert, closed system agriculture, economic botany in arid zones, veterinary medicine and animal husbandry in arid zones, the ancient desert agriculture and its lessons for today, the desert as human habitat, architectural aspects of city construction in the desert, the use of natural energies for comfortable living, the desert — a meteorological problem, will bring Israel's desert experts together for this symposium. There will be special ceremonies honoring Ben Gurion and his vision of such an institute, as well as field trips to Avdat, Arad, Massada and the Dead Sea, and Beer-Sheva and the main campus of the Ben-Gurion University of the Negev. Contact: Dr. Shabtai Dover, c/o Institute, Sede Boqer.

INTERNATIONAL CONFERENCE ON HOUSING PROBLEMS IN DEVELOPING COUNTRIES, December 18-22, 1978, Dhahran, Saudi Arabia, sponsored jointly by the International Association for Housing Science (IAHS) and the University of Petroleum and Minerals, Dhahran.

Topics: Major housing projects, systems approach, low-income housing systems, innovative design and construction schemes, new materials, specifications and codes, urban and site development, services technology, performance criteria, climatic factors, energy problems, environmental controls, public health, maintenance, finance and management, sociological and psychological factors.

Contact: Dr. Fahd H. Dakhil, Dean, College of Engineering, University of Petroleum and Minerals, Dhahran International Airport, P.O. Box 144. Dhahran. TELEX: 60060 UPM SJ; Cable: AL-JAMAAH DHAHRAN.

TECHNOLOGY APPROPRIATE TO UNDERDEVELOPED COUNTRIES, International Symposium of Engineering, sponsored by Universidad José Simeón Cañas, San Salvador, El Salvador, C.A., February 19-23, 1979.

Its objectives are announced as inquiries into the study of the technical aspects relating to technology use in underdeveloped countries, the promotion of native technologies appropriate to the socioeconomic conditions of such areas, an analysis of the technical, economic, social, political, and psychological barriers to research on the use of labor-intensive technology, and other aspects of this problem. Papers are welcome on such topics as pollution, technology transfer, computer technology, food technology, transportation, social-ethical aspects of engineering, man-technology transportation, and other related topics.

Contact: Ing. Ricardo A. Navarro, Coordinador General, Apdo. (01)168 San Salvador, El Salvador, C.A. Cable: UCASAL.

WORLD CLIMATE CONFERENCE, A Conference of Experts on Climate and Mankind, sponsored by the World Meteorological Organization WMO, February 12-23 1979, in Geneva.

There have been many scientific and technical conferences on the physical and geophysical aspects of climate. In contrast, the World Climate Conference will attempt to provide a definitive assessment of our current knowledge of climate and integrate this knowledge with knowledge from other disciplines to extend our understanding of the impacts of climate change and variability on human activities and our environment.

This Conference is a response by WMO and other UN agencies to the growing worldwide concerns about the impacts of natural variations in climate upon world food production, energy supply and demand, water resources, land use, and other aspects of society. It is also a response to the ominous significant changes in climate. There are now sufficient indications that some of these potential changes, such as those that might result from increased amounts of atmospheric carbon dioxide, could have a pervasive impact upon the nations of the world and may require unprecedented forms of international action to deal with them effectively.

During the plenary discussions, at the discretion of the chairmen of the individual sessions, discussion, comments, and questions from both the invited experts and the other participants will be entertained. The findings and recommendations of the Conference will therefore reflect a broad spectrum of views.

Contact: The Secretary-General, WMO, Case Postale No. 5, CH-1211 Geneva 20, Switzerland.

INTERNATIONAL CONGRESS ON WATER RESOURCES, 3rd, Mexico City, April 23-27, 1979, "Water for Human Survival."

Secondary subjects will be devoted to water for food production, for energy production, water and rural development, education and research on water resources, and water problems in modern society. Study tours are planned. Contact: Organizing Committee, Apartado Postal 19-434, Mexico, D.F.

ASSOCIATION FOR ARID LANDS STUDIES, joint meeting with the Western Social Science Association, Reno (North Lake Tahoe), Nevada, April 26-28, 1979. This interdisciplinary organization is comprised of social scientists and humanists with a common interest in arid lands teaching and research. Papers on all topics related to arid lands are welcome. Submit title and abstract before December 1, 1978, to program chairman Dr. Otis W. Templer, Department of Geography, Texas Tech University, Lubbock, Texas 79409.

??? DID YOU KNOW ???

•••that there is an *Australian Nomads Research Foundation* whose objective is to promote the welfare and advancement of the Aborigines of Australia, in particular the desert tribes living in that continent's extensive arid areas. Their main activities include:

- providing technical support and assistance for alluvial mineral investigations and mining,
- helping establish a private school which provides literacy and technical education for tribal Aborigines,
- designing and constructing housing suited to the social system of tribal Aborigines and the desert climate

It is hoped that several agricultural and livestock projects can be undertaken in future, including tribal plantings of jojoba seed imported from the U.S. Contact: Ian G. Wallis, Director, 388 Highett Street, Richmond, Victoria 3121, Australia.

•••that the Middle East's first camel clinic has been opened under the auspices of *Ben Gurion University of the Negev's* new veterinary hospital at Beer-Sheva, Israel? An Associated Press dispatch, September 14, 1978, described in an interview with Dr. Daniel Cohen, Director of the University's Institute for Desert Research Isan Center for Comparative Medicine, how visits are made to Bedouin encampments in the surrounding Negev Desert when the animals can't make it to the clinic. The camel veterinarian specialist, Dr. Shemtov Balli, who learned to treat camels in his native Iraq, points out that camels are not immune to viral, parasitic or bacterial diseases, all of which they can pass on to man. "Some diseases are dormant," he says, "but when man moves into the desert, we ought to know if any health dangers exist." On Tuesdays, the clinic sets up shop under a large metal overhand next to the hospital. "Usually I see the owners at the Arab market on Thursday, and they tell me to save a place for them," Balli goes on. And Cohen adds: "Science can increase the use of camels for milk and meat...This will be a starving planet, and camels do well in many areas where starvation will be a big problem. They eat many things that other animals do not, and they do not have to be near water at all times."

•••that there is an *International Disasters Institute* in the process of formation in England whose objective is to lessen the human impact of future disasters by 1) initiating, promoting and conducting research, 2) providing a consultancy service for field evaluations, and 3) providing an information and educational service for relief workers and agencies. Research carried out so far has amply demonstrated the potential for improving the type and timing of relief, for example:

...casualties: after earthquakes, the need for emergency medical care lasts for only a few days. Outside aid, if it is to be useful, must be of the right type and arrive during this critical period. Typically, vast quantities of inappropriate medicines are sent much later and never used

...famine: rarely predicted, food relief usually arrives after many starvation deaths have occured

...appropriate relief foods: as with medicines, large quantities of unnecessary foods are frequently airlifted to disaster areas at huge cost — e.g. in the Ethiopian famine of 1973, while there was a chronic shortage of funds and transport to move crucial grain in-country, jars of baby food containing up to 70 percent water were being airlifted from Europe

...emergency shelter: it is still commonly believed that imported short-term housing is vital for flood or earthquake victims — the kind of "aid" that uses up scarce money, arrives too late, and is often culturally and economically inappropriate

The Institute believes that field surveys, including a rapid assessment of casualties and needs following a major disaster; extension services for relief workers, such as training in effective assessment techniques; specific research projects such as the physiology of shelter and nutritional priorities in aid; and information services such as lectures, bibliographies, and liaison with the media are worthy immediate aims. If you are interested in supporting this idea, please communicate with Dr. Frances d'Souza, Director, London Technical Group, 85 Marylebone High Street, London W1M 3DE.

QUOTES

"...The future is not shaped by people who don't really believe in their future. It will be built by people who see the complexities that lie ahead but are not deterred; people who are conscious of the flaws in humankind but not overwhelmed by the doubts and anxieties of life; people with the vitality to gamble on their future, whatever the odds."

-John Gardner in *Frontline*, vol. 4, no. 3, p. 9, May-June 1978.

Central Arid Zone Research Institute (1978) Arid zone research in India. Silver Jubilee Volume, 1952-1977, published...on the occasion of the Silver Jubilee celebrations of arid zone research in India. CAZRI, Jodhpur.

Includes a profile of the Indian Desert by the Institute's director, Dr. H.S. Mann, plus articles on land use, vegetation and floral composition of the Rajasthan Desert, cultural heritage, desert development, human-animal interactions, perspectives on sheep production, wildlife resource and its management, role of forestry, forage crops, stabilization and management of sand dunes, role of dryland farming, arid zone soils, horticulture, etc.

Colorado State University, Fort Collins, Solar Energy Applications Laboratory (1977) Solar heating and cooling of residential buildings: Sizing, installation and Operation of systems. U.S. Department of Commerce, Economic Development Administration. Order: 003-011-00085-2. $7.00

Intended as a manual for use in a training course to develop the capability of practitioners in the home building industry covering: solar radiation, fluid heating solar collectors, thermal storage subsystems; effectiveness of energy conservation, retrofit considerations, buyers' guide, etc. Many maps, charts, tables, figures.

Desertification Control Bulletin, vol. 1, no. 1, June 1978- UNEP, P.O. Box 30552, Nairobi, Kenya.

This half-yearly bulletin is issued to keep the world community fully informed on the ongoing and planned activities in the field of combatting desertification. It is planned to give information relevant to the implementation of the Plan of Action, from which a clear picture should emerge of exactly which parts of the Plan are adequately covered.

International Conference on Guayule, 2d, Saltillo, Coahuila, Mexico, 1977 (1978) Guayule, reencuentro en el desierto. Consejo Nacional de Ciencia y Tecnologiá, Mexico 20, D.F. 436 p. ISBN 968-823-001-4.

The second Guayule conference, co-sponsored by CONACYT and the University of Arizona, brought together experts on the chemical, industrial, vegetal, medical, economic, and historical aspects of this rubber-producing shrub in the summer of 1977. Papers produced here are edited for publication, printed in English or Spanish, depending on their authors, but abstracts are given for each in the other language. The list of recommendations growing out of the conference include the need for a comprehensive policy for guayule development, establishment of plantations, development of an information center (there is one at the University of Arizona's Office of Arid Lands Studies), technical analysis of extraction processes, and other marketing and production practices. Dr. William G. McGinnies, active in the original U.S. Emergency Rubber Project during World War II, presents an "overview."

Long, G. et al (1977) Expérimentation sur l'utilisation des données LANDSAT pour l'étude écologique des zones arides de Tunisie. Premiers résultats. (Paper presented at) Canadian Remote Sensing Symposium, 4th, Québec, 16-18 May 1977.

Summarizes the experience of ARZOTU, launched in 1974, in several desert areas of Tunisia, covering approximately 50,000 sq k between isohyets of 100-350 mm rainfall. Objectives included an inventory of surface landforms, soils, vegetation, and ecology, as well as cartographic potential. Results are tabulated by areas and possible applications described, including monitoring desertification.

Mabbutt, J.A. (1978) Impact of desertification as revealed by mapping. Environmental Conservation 5 (1):45-56.

Maps prepared for the UN Conference on Desertification are critically reviewed, particularly the bases of their compilation what they can tell (as far as scale permits) about the extent and severity of the problem, and their potential usefulness in plans to combat desertification. Delineated areas at the risk of desertification as determined by bioclimatic stress, the inherent vulnerability of the land, and pressures of land use are examined. While the threat is shown to be highest beyond the margins of full deserts, the risk extends wherever drought marks the seasonal or periodic extension of aridity. Maps described in detail are: World Map of Desertification, Climate Aridity Index, Experimental World Scheme of Aridity and Drought Probability, Status of Desertification in the Hot Arid Regions, and Desertification Hazards Map of Africa north of the Equator.

Mabry, T.J. et al, eds. (1977) Creosote bush. Biology and chemistry of Larrea in New World deserts. Dowden, Hutchinson & Ross, Stroudsburg, Pa. xviii, 284 p. (US/IBP Synthesis ser., 6). $24.00

Contents: Adaptive strategies of Larrea; Geographic distribution, morphology, hybridication, cytogenetics, and evolution; Growth and development, form and function; Reproductive systems; Natural products chemistry; Anti-herbivore chemistry; Larrea as a habitat component for desert arthropods; Patterns of some vertebrate communities in creosote bush deserts; Structure and distribution of Larrea communities; Practical uses. Bibliography: p. 257-276.

Nabhan, G.P./Felger, S.R. (1978) Teparies in southwestern North America: A biogeographical and ethnohistorical study of Phaseolus acutifolius. Economic Botany 32 (1):2-19.

Ethnohistorically, wild and domesticated teparies are significant native food crops in southwestern North America. Their value rests in adaptations to arid environments, and high protein content and productivity. Use of wild teparies appears to be discontinued, but certain domesticated varieties are still grown by local commercial and subsistence farmers. Teparies have considerable potential for low maintenance agriculture in arid and semiarid lands.

Orians, G.H./Solbrig, O.T., eds. (1977) Convergent evolution in warm deserts. An examination of strategies and patterns in deserts of Argentina and the U.S. Dowden, Hutchinson & Ross, Stroudsburg, Pa. xvi, 334 p. (US/IBP Synthesis ser., 3). $25.00

Ozenda, P. (1977) Flore du Sahara. 2d ed. Centre National de la Recherche Scientifique, Paris. 622 p. ISBN 2-222-00292-3.

In the 20 years since the appearance of the original edition in 1958, much botanical research on the Sahara has been undertaken, reflected here in the greater coverage. As in the earlier edition, there are brief descriptions of world desert characteristics including the biology of desert vegetation, followed by the composition and origins of Saharan flora, the region's vegetative groups, and the use of plants by man in the Sahara. The greatest part is devoted to an analytical flora, including keys to families, brief descriptions of families, genera, and species, plus the distribution of species. Appendices cover definitions of botanical terms used, and alphabetical index of families, genera, and synonyms. Tables, maps, drawings, photographs.

Peterson, D.F./Crawford, A.B., eds. (1978) Values and choices in the development of the Colorado River Basin. University of Arizona Press, Tucson. 337 p.

Papers and discussions selected from a symposium held in 1974 sponsored by the Committee on Arid Lands of the AAAS. Divided into historical perspectives and future directions, coverage includes the physical setting, political aspects of the Basin's development, agriculture and salinity, energy resources development, role of agriculture, recreation, international problems, carrying capacity and planning, and a summary effort to enunciate a natural resource management policy for the future. The editors point out that the present situation is a result of a complex mixture of circumstances, determined partly by change, partly by the particular nature of the area's resources, and partly by societal choice, a mix that has led to lively conflicts that are apt to become increasingly serious with increasing pressure on the Basin's resources. Since the River is already almost completely utilized, hard political decisions and shifting values appear to be the order of the day.

Pitte, J.-R. (1977) Nouakchott, capitale de La Mauritanie. Université de Paris-Borbonne, Département de Geógraphie, Publication 5. 198 p. ISBN 2-901165-05-2.

As the capital of this last of the former territories of French West Africa to achieve independence (1960), Nouakchott represents in microcosm all the problems that such status imposes suddenly on a predominantly nomadic people, aggravated by the Sahelian drought of the early 1970s. This in-depth study covers the geographic, social, and political aspects of this coastal oasis as they impact on the country as a whole, including new mineral resources exploitation, and attempts at regional alliances with surrounding countries such as Senegal, Algeria, and Mali. The accompanying photographs, tables, and maps detail the growth and changing demographic parameters of this new society, while the bibliography itself reveals how little is actually known about its development and past.

Rouvillois-Brigol, M. (1975) Le pays de Ouargla (Sahara Algerien), variations et organisation d'un espace rural en milieu désertique. Université de Paris-Sorbonne, Département de Géographie, Publication 2. 389 p.

This exemplary and exhaustive study of the great Ouargla oasis, characterized by its one million palms, includes historical documentation relating to the occupance of the area at the edge of Algeria's Great Eastern Erg since the 8th century, its influence on the surrounding desert, the impact of oil discoveries to the east, and its present economy, demography, architecture, landscape, climate, and natural resources. Numerous tables of growth statistics, together with charts, both air and ground, plus maps and photographs. A comprehensive bibliography, and a very detailed index.

Sandford, S. (1978) Welfare and wanderers: The organisation of social services for pastoralists. Overseas Development Institute Review 1:70-87.

Considers the nature, content, and administrative requirements for the delivery of primary health and education services, and suggests some criteria for judging whether a particular form or method of delivering a service is appropriate. Describes some of the special problems of delivering social services to pastoral people and methods used to overcome such problems. Analyzes such factors as variations in the productivity of the environment which may make one method more appropriate in certain cases, but less so in others.

SEARCH: Journal of the Australian and New Zealand Association for the Advancement of Science, vol. 9, no. 7, July 1978. ANZAAS Inc., Box 873 GPO, Sydney, New South Wales, Australia 2001.

A special issue devoted to problems of desertification in Australia.

INTERNATIONAL VISITORS TO OALS/UA

ARGENTINA:
Pedro Luis Querio, Vice-President, Quitral-Co. SAIC, Buenos Aires, June 23, 1978

AUSTRALIA:
John Zwar, Superintendent of Parks and Greens, Corporation of the City of Port Augusta, South Australia, July 18, 1978

John S. Grant, Sunrich Oil Plantations and Nurseries, Victoria, August 14, 1978

CAPE VERDE:
Horacio Silva Soares, Director General of Conservation and Exploration of Natural Resources, Ministry of Rural Development, Praia, July 28, 1978

DENMARK
Jørgen Rald, Head of Department of Human Geography, Skive Seminarium, Skive, July 6, 1978.

ENGLAND:
Michael K.V. Carr, Lecturer in Irrigation and Crop Production, National College of Agricultural Engineering, Silsoe, Bedford, August 7, 1978.

FRANCE:
Jean-Baptiste Serier, Ingenieur Agronome, Institut de Recherches sur le Caoutchouc, Paris, July 24, 1978.
Michel C. Baumer, Special-Adviser, Institut des Amenagements Regionaux et de l'Environnement, Montpellier, August 21, 1978.

GERMANY:
Eckhard Wehmeier, Geographisches Institut, Universitat Stuttgart, Stuttgart, August 23, 1978.

ISRAEL:
Itzchak Ofer, District Officer, Soil Conservation Division, Ministry of Agriculture, Beer-Sheva, October 12, 1978.

Meir Forti and Ofer Heimann, Ben-Gurion University of the Negev, Beer-Sheva, October 12, 1978

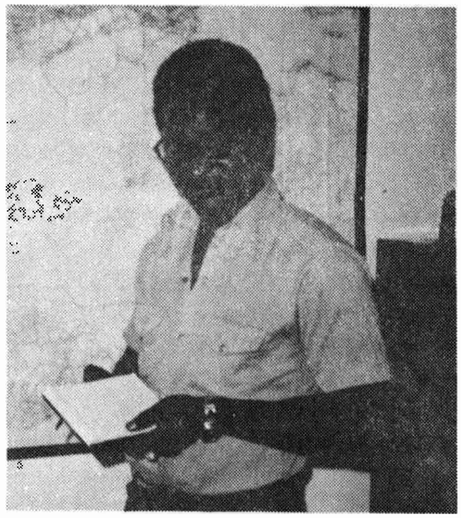
Meir Forti

ITALY:
Jelle Hielkema, Technical Officer, Scientific Exchange, FAO, Rome, July 14, 1978

JAPAN:
Ryozo Yamamoto, Professor of Crop Sciences, Nagoya University, Nagoya, August 14, 1978.

JORDAN:
Ibrahim Al-Saket, Professor of Soil Chemistry, Faculty of Agriculture, University of Jordan, Amman, August 2, 1978.

MAURITANIA:
Abderrahmane Touré, Director, Environmental Protection Service, Nouakchott, August 7, 1978.



Abderrahmane Touré

PEOPLE'S REPUBLIC OF CHINA:
A group of 10 geographers from the People's Republic of China, including The Academia Sinica's Institute of Geography, Changchun Institute of Geography, Kirin Province; Chengtu Institute of Geography, Szechwan; Peking University Department of Geography; Chunshan University Department of Geography, Canton; Institute of Desert Studies, Lanchow; Institute of Geography, Urumchi, Sinkiang; and the Kiangsu Institute of Geography, Naking, October 23, 1978.

SAUDI ARABIA:
Sulaiman Al-Sobaihi, Agricultural Projects and Development; Ministry of Agriculture and Water, Riyadh, August 21, 1978.

SOMALI:
Abdullahi Ahmed Karani, General Manager, National Range Agency, Mogadishu, June 1978.

SYRIA:
M. Nazir Sankary, Professor of Plant Biology, Faculty of Agriculture, University of Aleppo, September 1, 1978.

UPPER VOLTA:
Ouanini Luc Lompo, Director, O.R.D. Est, Fada N'Gurma, June 22, 1978.