Recycling of agricultural/industrial waste: The case of wastewater from sugar factories in the Sudan

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Agricultural industries in general and sugar manufacturing in particular use large quantities of water during the stages of washing and processing. The wastewater so generated is characterised by its high pollution loads in terms of BOD and suspended solids. This is due to the leakage of sucarose during processing and the accumulation of mud during washing. Treatment of this water can be efficiently carried out using Waste Stabilisation Ponds (WSP) from which the final effluent can be reused for irrigation in the cane fields. Wastewater produced at the Sennar Sugar Factory has been measured, defined and treated biologically. The results so obtained are encouraging for the reuse of effluents from the chosen unit for the treatment of agro-industrial wastes.

Introduction

The sugar industry started in the Sudan in the early 1960s with the commissioning of El Gunied factory in 1962 followed by Khasm El Girba (1965), Sennar (1976) and lately Kenana and Assalaya (1979).

The raw material for these factories is sugar cane. These factories have been located near the banks of either the Blue or the White Niles (Fig 1). This siting has solved the problems of obtaining water for irrigation of the cane fields and the processing of the sugar, but unfortunately, lead the sugar industry to believe that the simple way to dispose of the untreated effluents was into the Nile. The sugar industry uses large quantities of water for irrigation and processing (ie cane washing, cleaning water, condensers, boiler water, floor washing and other various cleaning processes). Consequently a large volume of wastewater is produced from the factory (Table 1).

The existing practice of disposal of the wastewater endangers the quality of the river Nile water and contradicts the Public Health Act adopted in 1975.

Therefore the objective of this study is to quantify the pollution load exerted by the sugar industry on the river Nile and to investigate the possibility of treating the wastewater with the intention of reusing it for irrigation. This will not only protect the Nile but will also save water and energy for the sugar industry. Water conservation through renovation and reuse could provide an economical and logical solution to the

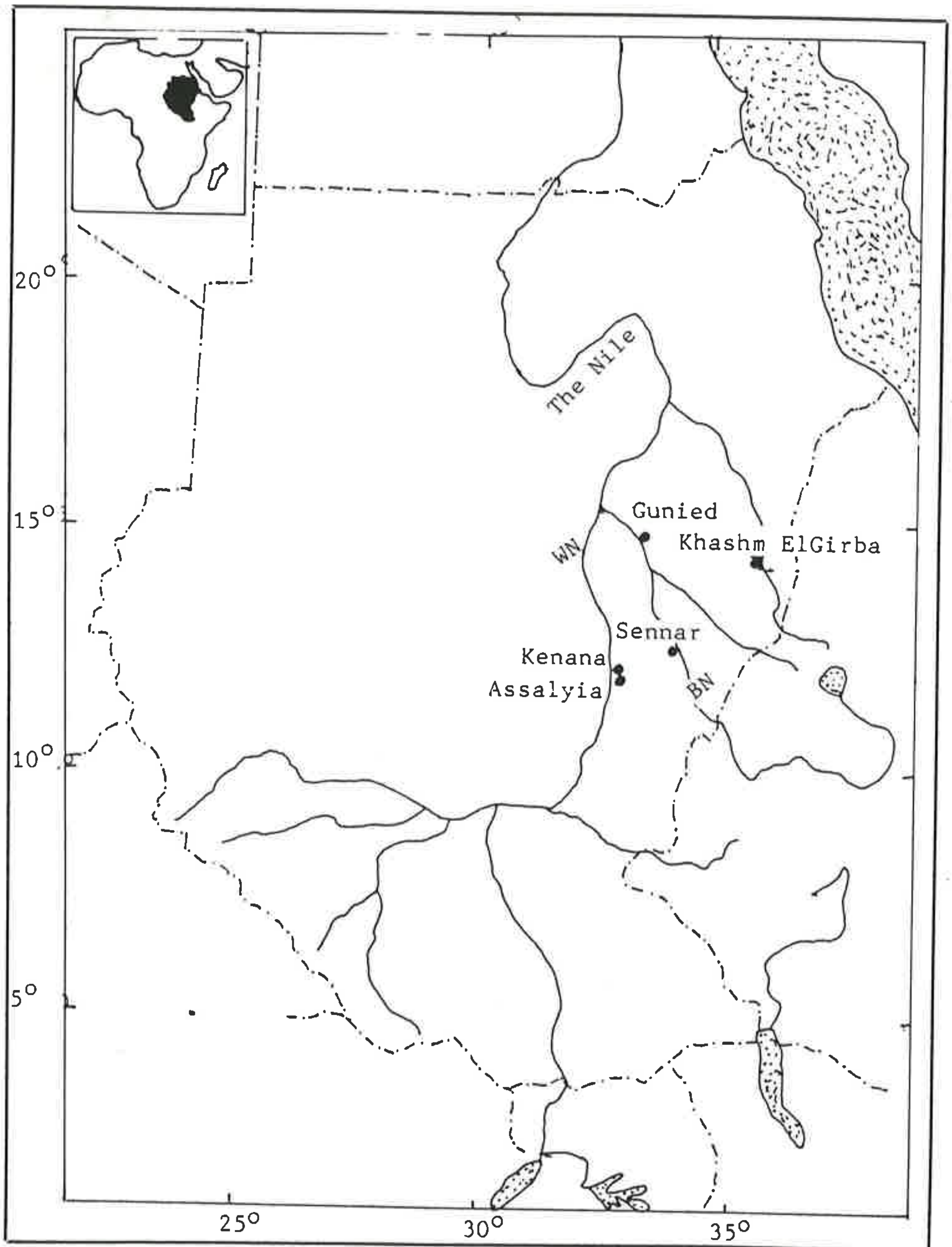

Fig 1 The Sudan — location of sugar factories.

Table 1

Wastewater Production

Factory	Design capacity (Ton/year	Wastewater m^3/h	Disposal Site
El Gunied	60 000	ND *	Blue Nile
Khasm El Girba	90 000	ND *	Blue Nile
Sennar	110 000	1100	Blue Nile
Kenana	330 000	980	White Nile
Assalaya	110 000	ND *	White Nile

*ND * Not Determined*

This paper was given at the International Conference on Water Resources, Needs and Planning in Drought Prone Areas, Khartoum, 6th–12th December, 1986.

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problem of sugar wastes where the water supply is scarce or inadequate, especially in countries such as Sudan.

In developing countries the choice of treatment units needs to be sound when related to the cost of the units, availability of skilled labour, man power, spare parts, training, and the supply of fuel and the necessary chemicals.

The units selected must be:
(i) simple to install and operate
(ii) convenient, manageable and easy to maintain
(iii) of reasonable cost and acceptable both environmentally and socially
(iv) rugged, robust, reliable and efficient

For these reasons, WSPs have been selected for the treatment of sugar wastes.

Treatment using WSPs is a low cost technique, as is the operation and maintenance. It requires less energy and highly skilled operators are not essential also the effluents meet the required standards. Being of simple construction with no mechanical or electrical equipment, WSPs are easy to maintain and cheap to install providing land costs are reasonable which is the case in Sudan.

Environmental factors such as soil conditions (especially permeability), climate (temperature, light intensity, precipitation, evaporation, wind speed and direction) play leading roles in deciding the design, operation and performance of these biological systems [6,8,11, 14]. Sufficient nutrients are essential to satisfy the high demand carbonaceous BOD to have proper plant performance and efficiency and to avoid troubles that may occur. Domestic sewage may be added to alleviate the problem or perhaps the recommendation of Lund [8] may be used; namely the addition of commercial ammonia and phosphoric acid to meet the required quantities of nitrogen (N) and phosphorous (P) as recommended by Gloyna[5] (BOD:N:P = 100:5:1) but this implies more costs.

Materials and methods

This investigation was carried out for the Sennar sugar factory during one processing season. The initiators for this study were the factory and the Ministry of Health. During the study the following tasks were carried out:

1 Wastewater streams originating from the different processing phases were identified, measured and analysed with the object of separating the contribution made by each stream as well as the final flow discharged to the Blue Nile (Fig 2).

2 A pilot unit consisting of screens, anaerobic, facultative and maturation ponds was designed, installed and operated. The performance of the unit has been determined on a weekly basis (Fig 3).

Table 2

Sennar sugar wastewater characteristics

Parameter	Discharge Points 1	2	3
*p*H		5.5	4
BOD, mg/l	1200	1800	1650
COD, mg/l	2160	1867	2400
TSS, mg/l	2080	790	1110
Oil & grease, mg/l	38	40	12
H^2S, mg/l	Traces	Traces	Traces
Alkalinity, mg/l	40	Not done	70
Acidity, mg/l	40	200	250
Chlorides, mg/l	10	20	12
PO^{4-}, mg/l	1375	640	390
Turbidity (NTU)	160	130	90
Conductivity, (μ mhos)	300	600	870

Discharge Point 1 : at the outlet of the factory
Discharge Point 2 : 10km away from the factory
Discharpe Point 3 : at the discharge point on the Blue Nile (26km from the factory)

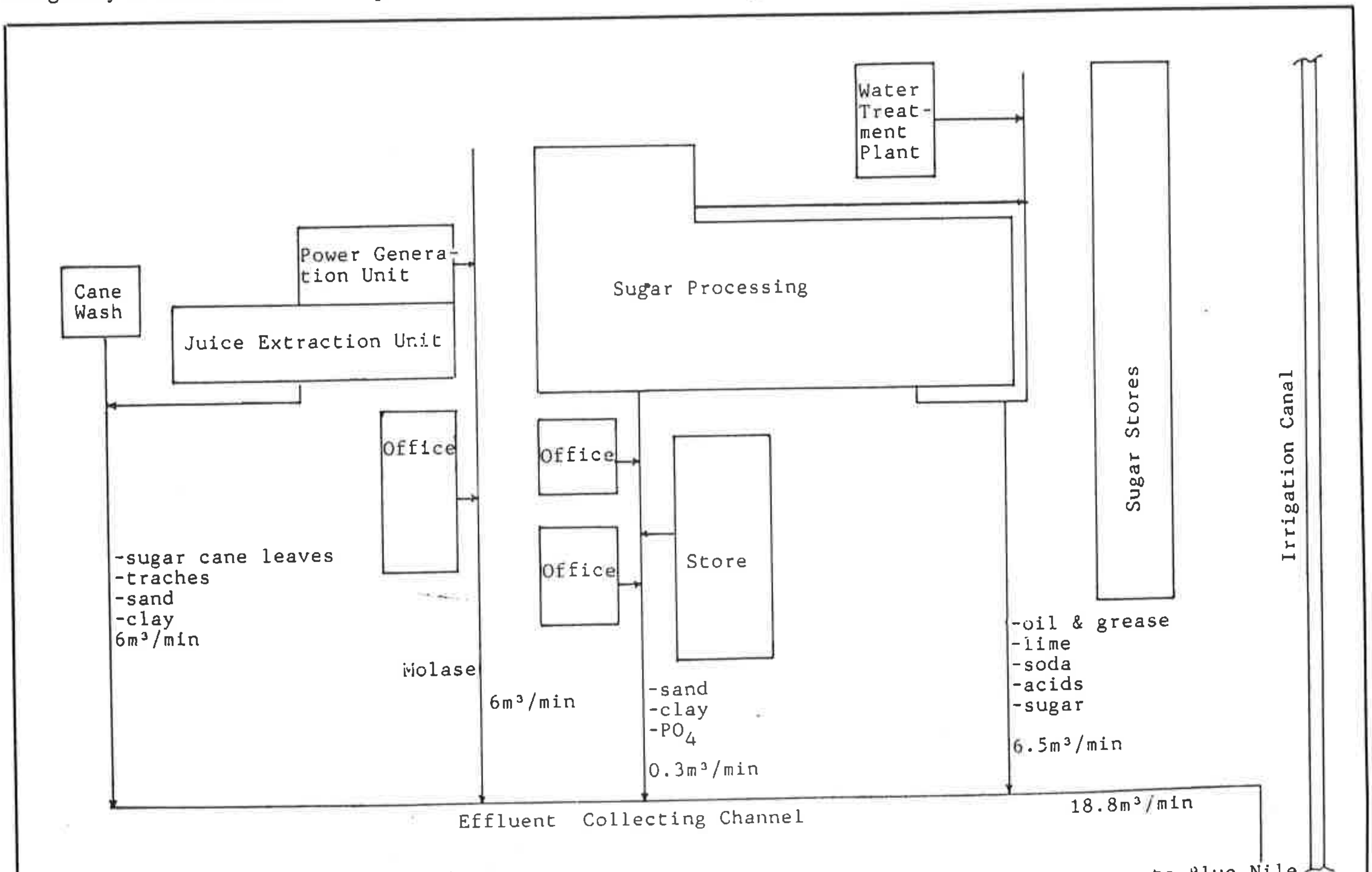

Fig 2 Plan of Sennar sugar factory drains.

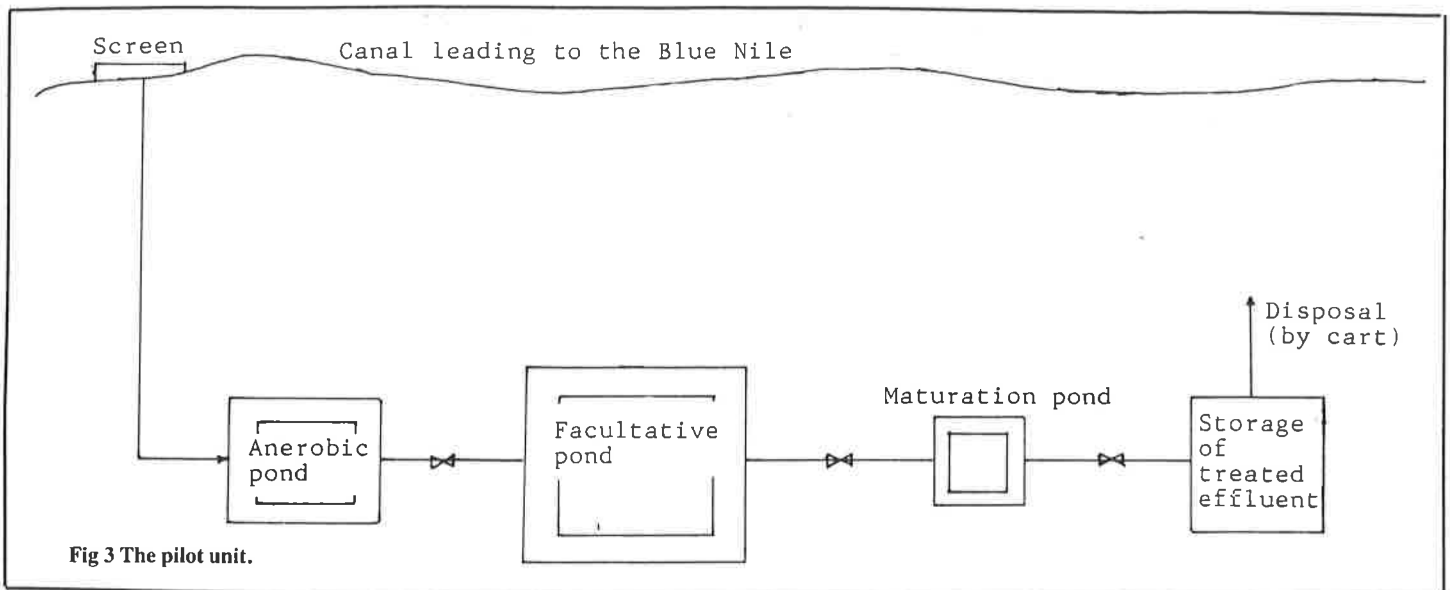

Fig 3 The pilot unit.

Results

The characteristics of the untreated final effluents were determined through the analysis of three grab samples. These samples were taken from three points on the canal which carried the waste from the factory to the Blue Nile. Results of these analyses are shown in Table 2.

The pilot unit

The designed unit was to treat 2 litres/min which is 0.01% of the total final effluent produced by the factory. The specifications of the ponds were as follows:

Anaerobic pond — (3.5 × 1.5 × 3m) with detention time equal to eight days.

Facultative pond — (1.5 × 9 × 4.5m) with detention time equal to three days and

Maturation pond — (1 × 4 × 2m) with detention time equal to three days.

It should be noted that the design identified waste which was strong, mostly biodegradable and mainly industrial.

The layout of the pilot unit is shown in Fig 3. Samples were collected weekly from the separated ponds and analysed for biochemical oxygen demand, total suspended solids, oil and grease and total phosphates with a view to determining the purification capability of the system. Results are shown in Fig 4.

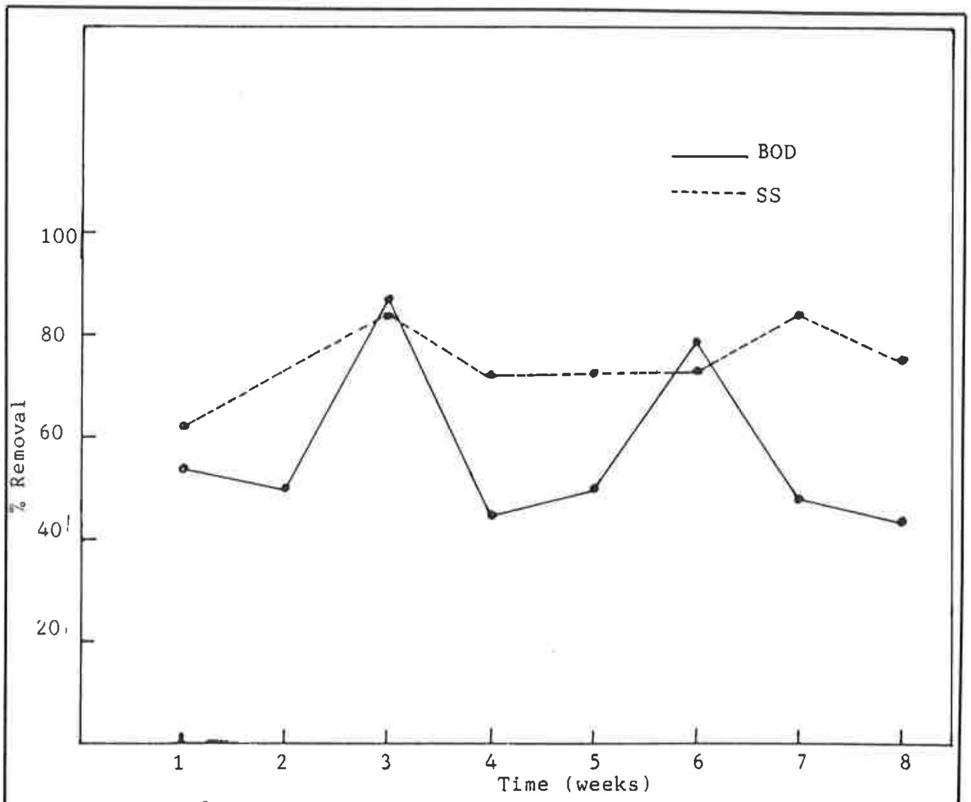

Fig 4 BOD & SS percentage removal in the pilot unit.

Waste stabilisation ponds may not meet effluent standards for suspended solids because of the presence of high concentrations of algal cells; but for BOD and bacteria reduction, ponds have little competition [5]. Viruses also were claimed by Ahmed [2] to die off in maturation ponds along with bacteria because the environment is hostile and unfavourable. Removal or reduction of algal cells content would impose added costs; but if the algal cells are reclaimed, recovered and dried, they may be used as an animal feed supplement.

In this investigation the achieved BOD removal amounted to 87%; while for other parameters the removability values amounted to 86%, for suspended solids, 94% for oil and grease, and 62% for phosphates.

Discussions and conclusions

Comparing the achieved final effluent quality with recommended quality for reuse of treated effluents for irrigation purposes, it can be concluded that these effluents can safely be reused. In order to increase the efficiency of such treatment plants for the sugar industry, it is recommended that good housekeeping should be enforced in the factories. This will minimise the waste produced and useful components such as oil and grease can be recycled.

However, these effluents can be mixed with irrigation water in the irrigation canals, where a dilution of more than thirty times can be achieved — thus reducing the possibility of any negative impact on soil and plants.

The results of this pilot unit have been used to design a complete large scale treatment plant with minimum additional units, and is ready for construction. The study and the final design are a model which is to be implemented by the sugar factories. By means of such industrial wastewater treatment plants, the river Nile can be protected against pollution that is now taking place due to current practices, and a lot of water and energy can be saved. It is worth mentioning that the possibility of irrigating artificial forests with treated effluents was considered and thought to be an alternative for making use of these treated effluents.

Application to land has many advantages: the organic matter is taken care of by the vegetation, bacteria by the soil, nitrogen being absorbed by the plantations, phosphorous gets absorbed into soil particles and exchangeable cations react with soil salts[2]. Nevertheless, any adverse changes in soil characteristics need to be monitored and countered (eg reduction in permeability).

When pond effluent is being used for irrigation, there may be objectionable odours resulting from accumulations of algae decaying as the water trickles through

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the soil or evaporates. Thus public health aspects and implementations of the reuse of effluents must always be kept in mind.

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إعادة تكرير المخلفات الزراعية والصناعية : قصة المياه المهدورة من مصانع السكر في السودان

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تستخدم الصناعات الزراعية عامة وصناعة السكر بوجه خاص كميات كبيرة من المياه خلال مرحلتي الغسل والتجهيز. يتسم الماء المهدور الناتج خلال هذه المراحل بنسبة تلوث عالية فيما يتعلق بحاجة معالجة المجاري إلى أكسجين الكيمياء الحيوية والجوامد المعلقة. ويعود السبب إلى تسرب السكروز أثناء التجهيز، وتراكم الوحل أثناء الغسل. ويمكن معالجة هذه المياه بكفاءة باستخدام أحواض تركيز الفضلات ، ومنها يمكن إعادة استخدام الدفق النهائي في ري حقول القصب. وقد تم قياس المياه المهدورة من مصنع سنار وتحديدها ومعالجتها بالكيمياء الحيوية. وتشجع النتائج التي تم الحصول عليها على إعادة استعمال مياه الدفق من الوحدة التي يقع الاختيار عليها لمعالجة الفضلات الزراعية الصناعية.