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BIOGAS

MOROCCO

The application of Biogas Technology to the treatment of industrial waste in Morocco

UNIDO Report carried out on behalf of the United Nations Industrial Development Organization

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CONTENT

1 USD ~ 9.5 DH (Dec 93), 1 DH = 100 CDH.

1. The Economic and Industrial Policy Framework for the Project in Morocco

Morocco has a population of 27 million. In 1992 gross domestic product per inhabitant amounted to around US$ 1050. Morocco's area comprises 716,000 km^2 of land of which two thirds are arid or semi-arid. A large part of agricultural land needs irrigation; water for it is scarce and often supplied from dams. Because of sandy soil characteristics, fertilizers which improve the soil structure are actively sought by the peasant population.

The industrial structure is dominated by primary industry. Morocco is the most important exporter of phosphate in the world, agriculture is the major generator of employment, and the fishing industry has witnessed rapid growth since the 1970s. The manufacturing industry is built up mainly around the transformation of the domestic raw materials. The production of fertilisers from raw-phosphate supplies the domestic market and accounts for more than one thirds of exports. The textile and leather industries have witnessed rapid growth during the 1980s, while the important agro-industry comprises sugar plants, olive oil, fish-,fruit-and vegetable canneries. Exports of fruit and of vegetables as well as food products from fish provide each about one seventh of export income. In addition to the fertilizer industry, heavy industry is found in the form of two oil refineries, nine cement plants and an iron and steel complex at Nador. Some car assembly plants exist producing French and Italian cars.

Economic reforms introduced in the beginning of the 1980s led to a modernisation of the economy and the elimination of a large number of subsidies to both production and consumption which had serious distortive effects on the economy. The policy was a success in terms of economic growth - between 1980 and 1992 the GDP of Morocco grew by about 4.5 percent per year - and in terms of a reduction in the public and the trade deficit. But the rapid growth of the population which grew at 2.7% per year undermined the growth per capita and created an increasingly difficult problem of unemployment which grew from 14% to 17% affecting above all the younger generation. 1 USD ~ 9.5 DH (Dec 93), 1 DH = 100 CDH.

During the 1990s the process of restructuring will be deepened. A problem to be addressed is that the level of competition in manufacturing industry is rather low. The state owns an important part of industry including the most important agroindustries, while the private industry serving the domestic market is protected behind solid tariff walls. In order to solve the problem, the Government intends to embark on a major privatisation programme and to lower tariffs exposing the industry to more competition.

What the privatisation process will mean for the use of biogas technology for the treatment of waste is as yet uncertain. In principle, the state can order a state company to employ a new technology at any time, whereas this obligation normally only is imposed on a private company when a production license is applied for. But experience has shown that most Governments are more likely to impose environmental restrictions on private companies.

2. The Institutional and Legal Framework for Environmental Policy

2.1 Status Quo for Environmental Policy in Morocco

Environmental policy in Morocco is still in its infant stage of development:

* Environmental consciousness is limited at both the political level and in the general public. Little grass root pressure exists for environmental improvements.
* The existing environmental legislation is old and insufficiently enforced.
* There is no independent ministry for environment nor an environmental agency, and very few staff in the ministries deal with environmental issues.
* There is little information available on levels of pollution and their impacts in Morocco, and little research is done.

This background poses obvious handicaps for the promotion of biogas technologies for the treatment of waste in Morocco. There is little political pressure on neither the municipal water and sewage utilities nor on the industries for the treatment of their solid and liquid wastes. The normal procedure is to dispose waste water directly into the rivers and the sea and to dispose solid waste on landfills unsorted and untreated. With the exception of the sugar industry - which in many ways is the elite industry in Morocco - industrialists are unconcerned with regard to the polluting impact of their production process. The use of cleaner technologies does not yet enter the investment planning process as an option to be considered; and management is extremely cautious with regard to giving environmental consultants access to their premises.

However, the situation is changing slowly. The environmental problems have become more transparent as they continue to intensify under the pressure of the growth of population and the economy. Environmental lobbying at international level has repercussions on the political scene in Morocco in the aftermath of initiatives such as the Rio Conference. Environmental impact studies, strategies and pilot projects in Morocco are being financed by international donors such as the World Bank, UNDP and the EC and by bilateral donors such as France, Germany, the USA and Sweden; these improve the information basis for environmental policy initiatives.

As regards the introduction of biogas technology for the treatment of organic industrial waste, the situation imposes a mixture of constraints and of opportunities:

- On the one hand although industrial managers interested in clean technologies no desperate need is felt as long as no governmental action is taken. The short objectives are therefore that the cheapest solutions are the best ones disregarding any environmental issue. This means that heavy subsidies will be needed to persuade managers to become pioneers in their application.

- On the other hand, however, the promotion of biogas will enter logically into the stream of initiatives by the international society and its environmental priorities. The managers are also open for any new technology from which the plant economy will benefit.

2.2 Institutional Framework for Environmental Policy in Morocco

As a logical consequence of the present stage of environmental policy in Morocco, also the public infrastructure for environmental administration is in its infancy:

* There is no environmental agency, the environmental units in the ministries are understaffed, rules for coordination are not well-defined and an excessively hierarchical structure makes cross-cooperation cumbersome.

* The sectoral ministries have neither a sufficient mandate nor a central, regional or local entity capable of participating actively in environmental management.

* Lack of expertise and, in particular, of procedures for the systematic techno-economic evaluation of project opportunities lead to the acceptance of sub-optimal options for projects.

The *Ministere de l'Interieur et de l'Information* is the central coordinating body for environmental management in Morocco. Within the ministry a *"Sous-Secretariat d'Etat pour l'Environnement"* position has been created with direct reference to the Minister of Interior. The "Division de l'Environnement" referrring to him is divided into three "services": "Sensibilisation et Communication", "Protection de la Nature", and "Pollution". The Division has a staff of ten persons, of which five are professionals. Another "direction" in the ministry provides assistance to local authorities in the planning of water and sewage systems. The *"Laboratoire Nationale d'Etude et de Surveillance de la Pollution et des Nuisances"*, a small but modern analytical laboratory is attached to the ministry. Its principal functions are environmental monitoring and control as well as work on norms.

The environmentally relevant sectoral ministries are:

* *"Travaux Publiques"* which, inter alia, is in charge of ONEP (L'Office National de l'Eau Potable") and of LPEF (Laboratoire Public d'Essais et d'Etudes)

* *"Ministere de l'Agriculture* et de la Mise en Valeur Agricole" (which inter alia, has the large *"Institute Agricole et Veterinaire Hassan II"* attached to it)

* *"Ministere de* l'Industrie" (which has a "Service de la Protection de l'Environnement" as a policy making and monitoring unit)

* *"Energie* et Mine" which has a "Cellule Environnement"

* *"Peche Maritime"*.

The *"Conseil National de l'Environnement"* was created in 1980 to ensure coordination between the activities of the Ministry de l'Interieur and of the sectoral ministries. But it has not yet been effective in this task.

At the *local administrative level*, one finds the "Prefectures" and the "Communes". In Rabat, the Prefecture has a "Service de L'Environnement" since 1989 which, with a small staff and limited financial resources. Each "commune" is supposed to have a "Cellule de Protection de L'Environnement" composed of administrators and technicians with expertise in the different technical areas needed for the task. But in general, the staff and the financial resources are very limited.

Numerous well equipped *laboratories* are found in Morocco, some of which are mentioned above. They provide sufficient capacity for the evaluation of physical and chemical properties in water, whereas the capacity for toxicological analysis and for the chemical analysis of biotasks is as yet limited. But since the educational system is of good quality, the shortcomings can be overcome through proper on-the-job training.

The introduction of biogas as a technology for the treatment of industrial waste would touch the field of interest of all the above mentioned ministries:

* L'Interieur for being an environmental technology with a rather broad cross-sectoral application

* L'Industries for its application in the agroindustry

* Travaux Publiques for the treatment of municipal wastewater and household waste

* Energie for being a renewable energy technology

* Agriculture for being a supplier of compost for farmers

* Peche for its use in the fish conserves industry

The large number of potentially interested parties poses a potential coordination problem. The ministry which is nominated as the lead counterpart for a biogas programme for waste treatment must keep the other ministries well informed of the initiatives that are undertaken. But because of the broad interest one should expect the different ministries to provide active support to the programme.

2.3 Legal Framework

A recent World Bank study identified about 350 different laws of relevance for environmental management in Morocco[1]. The key laws were old - dating back to the 1914-36 period, while a modern draft environmental law has been in preparation since 1986 without immediate perspectives for adoption.

In principle, however, the existing *primary legal framework* ("les lois" needing adoption by parliament) permits the authorities to comply with the environmental tasks demanded in a modern society although a few legal "lacunes" were identified:

- there is no general law making it obligatory to provide an integrated control of all types of pollution

- laws concerning the control of chemical products in general

- laws concerning the control of dangerous waste

The weaknesses are found, firstly, at the level of the *secondary legal framework* (les "textes applications" in the form of "decrets" and "reglements" which are adopted by the cabinet or the ministries). The Government has not made sufficient use of the scope of maneuvre provided by the primary legal framework to implement environmental policy priorities in the form of

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1 Projet de Gestion de l'Environnement. Etude Institutionelle, Juridique, et de la Pollution", Decembre 1992 prepared by SWEEP-Scandiaconsult.

directives. Secondly, there are hardly any *environmental norms* (legal or otherwise) except for a few hygienic norms for water and for norms on sulphur content in fuels.

The absence of stated environmental policy objectives and of norms for discharges and their enforcement by local and national authorities poses an obvious problem for the introduction of any anti-pollution technology including biogas technology for waste treatment. In such a situation the logical strategy is to focus on the implementation of a few demonstration projects for "win-win" pollution control technologies, that is, technologies which not only yield environmental benefits to society but also financial benefits to the industrial investor. Biogas systems installed in individual industrial plants for the treatment of their organic waste fall into this category.

2.4 Environmental Policy Priorities

At the moment, the Government does not yet have an active environmental policy with stated priorities. A "Strategie de l'Environnement" financed by UNDP and executed by UNESCO is under preparation and UNIDO is seeking a donor to finance a project called "DIED - Dèveloppement Industriel Ecologiquement Durable". The World Bank financed "Projet de Gestion de l'Environnement" ranked the following types of pollution as the most important listed by order of priority:

* land pollution by pesticides, fertilizer and other agents

* pollution of underground water resources through nitrates

* pollution of the sea and of beaches

* pollution of surface water by phosphates, fecal matter, chrome
* air pollution, above all in cities (SO_2, lead)

The study concludes that the primary priorities for intervention are (i) to handle the heavy metals, in particular chrome, which most of all comes from tanneries and (ii) the "margines", the liquid waste product from olive oil production which is acid and salty. The second priority is the biological treatment of biodegradable waste from the cities and from industries which is disposed into the river environment.

At the level of the communal authorities, the primary environmental concerns relate to the disposal of solid waste and of waste water.

It can be concluded that the promotion of biogas technology for the treatment of industrial waste matches the needs of environmental priorities in Morocco.

3. Energy Policy in Morocco

The issue of energy supply and consumption has for a long time drawn active political attention. Morocco is 90% dependent on external sources of supply for its commercial energy demand which in 1990 amounted to 6.5 mtoe of which 77% was covered by petroleum products. The national energy policy aims to achieve three objectives:

* The *reduction of dependence on foreign sources of energy supply* through the promotion of domestic energy resources (hydroelectricity, prospection for hydrocarbons, exploitation of bituminous resources, promotion of renewable energy resources)

* The *substitution of oil consumption* through the intensification of coal and natural gas consumption in the power sector and the cement industry

* The *promotion of energy savings* through the implementation of a national energy saving programme and a high taxation of fuel consumption.

Due to the high taxation of fuels for residential as well as industrial consumers, the prices charged for energy are among the highest in the world. In October 1993 prices were:

* Power tariffs were 68 CDH/kWh for distribution companies, 71 CDH (UScents 7.5) for industrial consumers, 92 CDH for medium voltage ordinary consumers and 73 CDH for low voltage ordinary consumers (households).

* Gasoil cost 3869 DH/tonne or 4 DH per litre (UScents 42).

* Fueloil depending on quality cost around US$ 200/tonne

Until 1993 the state enterprise *ONE, L'Office Nationale de l'Electricite* has had a monopoly for the production and the transmission of power. Distribution is in private hands. The Societe Marocaine de Distribution SMD and its subsidiaries supplies the large cities, the Societe Cherifienne d'Energie the small cities with the Entreprise Electrique de Zenata-Mohammadia and Entreprise Electrique La Banlieu de Marahed providing their respective regions.

Although the largest industries such as the phosphate and sugar producers have invested in *cogeneration* for autoconsumption, ONE has discouraged investments in cogeneration by refusing to pay anything but very low prices for the purchase of privately produced power. The failure of power sector investments to catch up with the 7% annual growth in demand and the effect of draught on water reservoirs in hydrodams have led to substantial power rationing. However, this policy will be changed in the near future by the Government, which intends to oblige ONE to purchase surplus power from cogeneration at prices likely to reflect avoided cost estimates. In addition, ONE is about to lose its monopoly for production. Two large international consortia are willing to invest in two major power plants in the 600 MW size provided that agreement can be reached on adequate prices for the produced electricity.

Renewable energy is actively being promoted by CDER - "Centre de Developement des Energies Renouvelable" (under Ministere de l'Energie) which has initiated projects in the areas of solar energy, biogas and wind power mentioned by order of priority.

The most important *energy saving programme* is a USAID financed *GEM project for industrial energy audits* which started in 1989. The programme has been active in three areas: Promotion of awareness building for energy savings, training of engineers and technicians in the implementation of energy audits, and the implementation of energy audits in hotels and industries. In the agroindustrial sector energy audits were undertaken in the sugar industry, dairy industry and the conserves industry. Recently, USAID has taken the decision to extend the programme to include a cleaner technology component - industries asking for an energy audit will be offered to receive a free environmental audit. The programme has made a valuable contribution in awareness building, training and in offering energy audits on a private sector basis. But although the energy audits showed investment possibilities with internal rates of return in the 20-80% range, the implementation rate of the recommendations has been low. The protected industries make good profits and energy costs make up too small a fraction of the cost of production to incite major interest by management.

The GEM-project will be an interesting collaboration partner for the promotion of biogas waste treatment technology:

- It has experience with advisory services to industry and seems to be trusted by industrial managers

- Its combined energy/environmental audits can include recommendation for investments in organic waste treatment plants whenever this is a financially attractive option

The GEM project ought to be motivated for collaboration. The biogas option can lead to a substantial increase in the reduction of commercial fuel consumption in an industrial plant; and in addition the environmental objective is promoted.

It can be concluded that the energy policy in the country favours the introduction of biogas for waste treatment:

- High energy prices improve the financial value of biogas investments for industries that can make use of the biogas production obtained from the treatment of its waste to cover some of the demand for heat and power.

- An active policy to promote cogeneration will lead to attractive prices for sales of surplus power to the grid.

- The CDER actively promotes biogas systems in its overall renewable energy programme

- The project will reinforce the energy saving initiatives launched in the country.

4. Biogas Technology and the various types of waste in Morocco

4.1 General

Biogas technology can be of use in the following four sectors:

1. Biogas in rural areas
2. Treatment of municipal solid waste
3. Water treatment and sewage treatment
4. Waste from the agro industry

In the present study it has not been possible to give a complete description of the biogas technologies' potential in all these sectors in Morocco. The focus of this study has been to evaluate the possibilities of the so called win-win projects based on waste from the agro-industrial sector. However, to give some kind of reference a short description is given below which includes reference to the use of biogas technology in the other sectors.

4.2 Biogas in rural areas

The history of the introduction of biogas in rural areas starts in 1983 where a programme was initiated together (CDER, ORMVA-HOUZ) with the Chinese authorities. This programme included the construction of 350 biogas digesters in Morocco. One of the main objectives of this programme was to avoid deforestation by replacing wood, traditonally collected to be used as fire-wood for cooking, with biogas produced from animal manure. This programme, however, ran into many difficulties, basically because it was not possible to transfer Chinese experiences to conditions in Morocco. Among these difficulties can be mentioned:

- insufficient local training
- weaknesses in the technical installations
- wrong choice of location of the units
- lack of motivation among the persons to deliver manure to the biogas unit and apply the biogas for cooking
- insufficient production of biogas from the units to be used for traditional cooking in Morocco

The GTZ became involved in a new adapted biogas programme together with CDER and ORMVA-Souss Massa. This programme has been much more successful, and so far 20 units have been built with a reactor volume of 10 - 100 m^3. As one of the examples the little unit at Ait Amira, 25 kilometres south of Agadir can be mentioned. This unit has a reactor volume of 12 m^3 and can handle manure from about 5 - 6 cattle daily (250 kilos). The daily production of biogas from this unit has been measured to about 2 m^3 per day or 1 cubic metre during the winter and 3 m^3 during the summer. The biogas is used in one lamp and one burner. The investment, including equipment and labour, has been USD 620 for this unit. It replaces a butane gas burner. The cost of the butane gas has alone been estimated to be USD 125 yearly.

Another unit has been constructed near Ichaden with an active reactor volume of 85 m^3. A little farm with 20 people and 34 cattle and with 10 hectares of agricultural land provides the input mainly in form of manure to the digester. Like most farms in Morocco the farm is not connected to the public electricity grid. Electricity is provided by a gas oil motor that delivers electricity for the farm for household use and to an electric water pump. About 70 % of the gas oil used (25 litres per day) has been replaced by biogas. The investment, including labour costs of the unit has been USD 9.000, and the annual savings in gas oil amounts to USD 1.800. The treated manure is used as fertilizer in the neigbouring fields. The Souss Massa region contains approx. 122.000 cattle. Based on distribution on smaller and bigger farms it is possible to make a total Table showing the needed types of biogas digesters.

Digester volume and number of farms

Number of cows	Number of farms	Volume digester
4 - 6	7146	12 m^3
7 - 9	4422	20 m^3
10 - 16	4584	30 m^3
17 - 27	2346	50 m^3
>> - 28	1416	>85 m^3

If all these biogas digesters were built, the potential of biogas production in the Souss Massa region alone would be around 30 million m^3 per year in the Souss Massa region. Morocco has approx. 3.400.000 cows, thus giving a potential biogas production of 850 million m^3 per year or 510 million m^3 of methane or half a million tonnes of oil. It is, however, also clear that even only a fraction of this potential cannot be achieved without a major effort and investment. The GTZ/CDER/ORMWA programme has shown that simple constructions can work in Morocco. There are, however, many factors that should be taken into account before it is possible to implement a major programme in this area. Among these factors can be mentioned:

1. A long term national strategy must be formulated

2. National incentives must be introduced

3. The local persons must be motivated for maintaining the biogas digesters and these must be constructed in a way that makes the deposit of manure an easy daily routine

4. The costs of the digesters must be covered by risk willing capital

5. The technical problems seen during the winter months with relatively cold temperature and a small production must be solved.

6. A sufficient numbers of technicians with knowledge of biogas technology, must be available locally

4.3 Municipal Waste

The amount of household waste from the major cities in Morocco has been estimated. The table below shows the data from various cities. In general the percentage collected varies between 70 - 85. A daily total of 3.800 tonnes of household waste is deposited in the major landfills around the cities. All together household waste amounts to around 8.000 tonnes per day from the cities in Morocco. The household waste is characterized by having a relatively high humidity content, in general approximately 70 %. This is due to the fact that the kitchens in Morocco normally use substantial amounts of vegetables. The high humidity content naturally makes it more expensive to incinerate the waste. So far no incineration plants have been built in Morocco. Three cities, namely Marrakesh, Rabat and Meknes produce compost from household waste. The compost is of a relatively poor quality and is sold to the farmers at a price of 40 DH per tonnes. It is uncertain whether a market for this type of compost exists unless the quality of the compost is improved. The farmers complain of large amounts of plastic waste in the compost which consequently pollutes the fields. A new compost unit is under construction in Agadir.

Table

Household waste	Population	Percent collected	Production kg/h/d	t/d
Casablanca/Mohammedia	3.900.000	80	0.6	1900
Rabat/Salé	815.000	80	0.6	400
Fes	725.000	70	0.6	320
Meknes	500.000	80	0.6	250
Oujda	380.000	80	0.6	200
Marrakech	640.000	85	0.6	350
Tanger	410.000	85	0.6	230
Tetouan	290.000	75	0.6	150
Total from these cities				3800

The potential for producing biogas from solid household waste has not been examined in Morocco. One should, however, regard this as a potentially interesting possibility. One could compare and apply the results from the study "Environment and use of methane from municipal waste" compiled for UNDP/GEF in August 1993, regarding the use of household waste from the city of Amman. The situation outside some of the major cities in Morocco is very similar to the situation with household waste from the city of Amman. It is possible to use part of the household waste in a biogas plant. The technology has been very well developed and improved during the past decade. The advantage compared with a compost unit is that when using an anaerobic process biogas is obtained in addition to fertilizer. If a thermophilic process is chosen an excellent quality of fertilizer is the result. Based upon the cost of the compost unit in Agadir it seems possible to construct a similar biogas plant for the same amount of money with the same capacity for producing fertilizer and with an electricity generation based on biogas production of about 1 MW, based on a daily input of around 60 - 70 tonnes of household waste.

Segregation of the waste for a biogas plant is very similar to what is needed for compost unit. As the authorities in Morocco are considering improving the compost unit and building new ones around the major cities it should seriously be considered whether biogas plant units could be constructed instead. This would produce the same amount of fertilizer plus a production of biogas of approx. 400 m^3 CH_4 per tonne of household waste. This household waste can be a mixture of segregated household waste, vegetable market waste, slaughterhouse waste and maybe chicken waste as well as waste from expired food.

The project proposal includes a project for a biogas unit that could be placed outside any of the major cities, but the possibilities would be best outside either Casablanca/Mohammedia or Rabat. The unit would be able to produce 28,800 tonnes of fertilizer per year with a sales price of 50 DH per ton giving an income of 1.440,000 DH per year or USD 151,600. This fertilizer could be sold to the nearby farmers and greenhouses. In addition 1 MW of electricity could be produced.

4.4 The Treatment of Waste in Morocco

Treatment of waste water

Treatment of waste water in Morocco is until now a purely rural phenomenon. No cleaning plants are found in the larger cities. In the rural area, the scarcity of water for irrigation has led to the construction of about 50 waste water cleaning plants since 1958. During the 1960s and 1970s, the aim was to protect the recipient aquatic environment against organic discharges and socalled "compact" units were built [2]. Very few of these are still in use. The sludge which they produce has to be dried and evacuated regularly. The municipal plants failed to comply with this task and were closed down, whereas plants in private or para-public hands faired better in this aspect. Since the 1980s, higher sanitary requirements and the wish to use the cleaned water for irrigation purposes has led to the construction of socalled "systèmes extensifs" [3]. Among these, the "soil purification methods" (consisting of a dègrillage grossier", a basin for anaerobic stabilisation, a basin for temporary storage and a desinfiltration basin of sand dunes) seems to have given the most promising results. The cost of treatment not including a financial charge for the use of land is about 2.5 DH per m^3. As the system requires large areas of land - Agadir in the year 2000 would need a 150 ha plant for its full water cleaning needs - this cost could become rather high in larger urban areas.

5. Identification of Agro-Industries where Biogas Technology can be Applied

5.1 Sugar plants and destilleries

In Morocco there are 13 sugar plants treating both sugar cane and sugar beets. The installed capacity in each of the plants can be seen in the Table below. These plants can treat 3,4 million of tonnes of sugar beets and 1.200

2

The three main types which have been used are: The "dècanteurs-simples or dècanteurs-digesteurs", the "boues activès", and the "lits bactèriens".

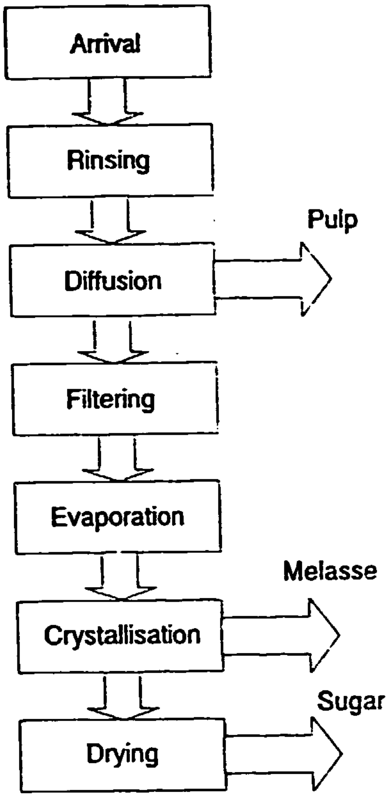
million tonnes of sugar cane per year. This corresponds to a maximum sugar production of about 550.000 tonnes per year. During the years from 1988 - 1990 the average yearly production nearly has been 480.000 tonnes. The sugar consumption in Morocco in these years have been 730.000 tonnes. This means that Morocco imports approximately 33 % of the sugar needed for domestic consumption. Much sugar is used in the traditional Moroccan kitchen and the sugar demand has more or less doubled from the year 1960 to 1990. The first sugar plant in Morocco came into production in 1963 and some of the plants are quite new. The newest is from 1982. Due to a relatively low price of sugar on the world market there are no immediate plans for construction of new units.

Sugar factories in Morocco

	Sugar factories	Location	Establisment/ date	Daily Capacity approx.
GHARB	SUNAB	SIDI SLIMANE	1963	3000 t(B)
	SUNAG/KSIRI (SUNAG 1)	MECHRAA BEL KSIRI	1968	4000 t(B)
	*SUNAG/TAZI (SUNAG 2)	SIDI ALLAL TAZI	1968	4000 t(B)
	SUNACAS	MECHRAA BEL KSIRI	1975	2500 t(C)
	SURAC	DAR EL GUEDDARI	1981	3500 t(C)
TADLA	S U T A	SOUK ES SEBT	1965	3600 t(B)
	S U B M	BENT MELLAL	1969	4800 t(B)
	S U N A T	OULAD AYAD	1971	6000 t(B)
DOUKKALA	DOUKKALA	SIDI BENNOUR	1970	4000 t(B)
	ZEMAMRA	KHEMIS DES ZEMAM-RA	1982	4000 t(B)
LOUKKOS	SUNABEL	KSAR EL KEBIR	1978	4000 t(B)
	SUCRAL	LARACHE	1984	3500 t(B)
BASSE MOULOUYA	SUCRAFOR	ZAIO	1972	3000 t(B) 1000 t(C)

B = sugar beets
C = sugar cane

The Process of Sugar Production



As an example of a sugar plant in Morocco the SUNAG 2 plant was studied. The plant is located at the Sebou River approximately 50 kilometres from the city of Kinitra. The plant treats sugar beets and the harvest period is from mid May to mid August. During this period a plant works 24 hours a day, treating around 300.000 tonnes of sugar beets. The plant was constructed in 1968 and has an installed capacity for treating 4.000 tonnes per day. The sugar production based on 300.000 tonnes of sugar beets is 45.000 tonnes of sugar, 18.000 tonnes of pulp and 26.000 tonnes of melasse. The waste water from the sugar plant amounts to 200 cubic metre per hour during the campaign. Approximately 150 cubic metre of water is taken in per hour, the rest is comes from the sugar beets during the process. This is naturally quite a substantial amount of waste water. The COD in the waste water is about 3.500 milligrammes per litre.

The plant uses coal for heat production and during the campaign approximately a total of 21.000 tonnes of coal is used. Some of the steam is used for electricity production. The plant itself has an installed electricity production unit with a capacity of 6 MW. At present all waste water from the plant ends in the Sebou River without treatment.

SOTRAMEG is the sole destillery in Morocco. It is located as a neighbour to SUNAG 2. It is, however, an independent company but both SUNAG 2 and SOTRAMEG are government owned. It produces about 5.000 cubic metre of alcohol per year based upon melasse received from SUNAG 2. The waste water from the fermentation and destillation is about 10 cubic metre per hour and the plant is working 8 - 10 months a year. The waste water has a very high concentration of COD i.e. 60.000 milligramme per litre.

Untreated waste water is collected in large basins close to the plant. This practice has led to odeur nuisances and pollution of neighboring wells. The waste water eventually ends up in the Sebou River.As an example of a sugar plant in Morocco the SUNAC 2 plant was studied. The plant is located at the Sebou River approximately 50 kilometres from the city of Kinitra. The plant treats sugar beets and the harvest period is from mid May to mid August. During this period a plant works 24 hours a day, treating around 300.000 tonnes of sugar beets. The plant was constructed in 1968 and has an installed capacity for treating 4.000 tonnes per day. The sugar production based on 300.000 tonnes of sugar beets is 45.000 tonnes of sugar, 18.000 tonnes of pulp and 26.000 tonnes of melasse. The waste water from the sugar plant amounts to 200 cubic metre per hour during the campaign. Approximately 150 cubic metre of water is taken in per hour, the rest is comes from the sugar beets during the process. This is naturally quite a substantial amount of waste water. The COD in the waste water is about 3.500 milligrammes per litre.

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SOTRAMEG is the biggest destillery in Morocco. It is located as a neighbour to SUNAG 2. It is, however, an independent company but both SUNAC 2 and SOTRAMEG are government owned. It produces about 5.000 cubic metre of alcohol per year based upon melasse received from SUNAC 2. The waste water from the fermentation and destillation is about 10 cubic metre per hour and the plant is working 8 - 10 months a year. The waste water
has a very high concentration of COD i.e. 60.000 milligramme per litre.

Untreated waste water is collected in large basins close to the plant. This practice has led to odeur nuisances and pollution of neighboring wells. The waste water eventually ends up in the Sebou River.

Several possibilities for treating the waste water from the SUNAC 2 sugar plant as well as the SOTRAMEG destillery have been considered:

1. Extensive treatment by constructing a natural lagune with the possibility of introducing aeration

2. anaerobic treatment with active sewage has been considered as well as using a sequential biological reactor.

The SUNAC plant works from mid May to mid August and the SOTRAMEG plant works more or less the whole year. It seems logical to make a joint treatment unit for the waste water which amounts to 210 cubic metre per hour during the peak period. It would also be advantageous to divide this treatment unit so only a part of it is used during the period when only the SOTRAMEG plant is working. When choosing the treatment system it is, however, important to make use of recent results regarding which reactor to use and how the process can be established. The previous proposals have very much focused on the issue of cleaning the waste water without taking any benefits from newer systems into account. Using for instance a UASB reactor system one could with a reactor volume of about 2.500 cubic metre treat the amount of waste waster (210 cubic metre per hour). It can also be estimated that with this system it will be possible to produce about 12.000 cubic metre of methane per day. This again corresponds to 1.8 MW if used for electricity generation and about twice that amount of heat. In the following chapter a description of how to develop a project based on anerobic digestion for the SUNAC/SOTRAMEG plants is presented.

5.2 Fish Conserves Industry

Morocco has a very long coast line (about 3000 km) and the fishing industry has always been a very important industry for Morocco. It is one of Morocco's major export industries and there has always been an important industry in Morocco, in the fish conserves sector. The most important fish being treated are sardines, mackerels, anchovies and tuna.

According to the statistics of 1993 the fishing industry includes 64 conserving plants. The most important are to be found in the cities of Safi (50 %) Essaouira (11 %) and Agadir (34 %). The theoretic capacity of these installations are approximately 1.600 tonnes of fish per day. Given a year with approximately 250 working days this gives a total yearly capacity of these 64 plants of 400.000 tonnes of fish. During the years 1980 - 1989 the actual number of tonnes treated has been 103.000 tonnes yearly.

When treating the fish the head is cut off, and the blood and part of the intestines are washed out with the waste water. The actual amount of the fish that is being used is for conserves varies among the fish species. In the case of the sardines measurements show that approximately one third of the actual weight of the fish when caught is ending in the conserves. Another third is cut off and can be regarded as semi solid waste, head etc. The remaining third of the fish weight when caught is washed away with the waste water. As mentioned the amount of fish being used varies. Statisticly one can calculate that in the years 1980 - 1989 the weight of the fish in the conserves was around 51.000 tonnes per year. With an input of 103.000 tonnes this means that about 50 % of the fish treated ends up as waste, either in the waste waster or as semi solid waste.

	3600 t/y fish	
1200 t/y	1200 t/y	1200 t/y
used	in the waste water	semi solid
↓	↓	↓
10 t/day	10 t/day in 60m^3 water	sold to a fish oil plant for 22 CDH/kg

In order to evaluate the possibility for using the waste from the fish conserves industry, an investigation has been made by using input from a specific fish conserves industry, Espadon, placed in Agadir. This plant process between 3.200 - 4.000 tonnes of fish each year. According to the plant manager the plant operates normally 120 days per year. The treatment of fish can be seen from the Table below. Out of the 3.600 tonnes per year only 1.200 tonnes end up as canned fish (10 tonnes per day). The rest can be divided in around 10 tonnes per day that are washed out with the approx. 60 m^3 of waste water. The semi solid part, the heads etc. around 10 tonnes a day, is sold to a fish oil plant nearby for 22 CDH per kilo. The COD of the waste water is around 20.000 milligrammes per litre. If this waste water was treated in an UASB reactor, it could give a production of approx. 500 m^3 of methane per day. At present this waste water is deposited directly into the bay of Agadir, which is a major tourist resort. In the plant itself about 120 tonnes of fuel oil is used per year and the costs of the fuel oil is around

450.000 DH. The electricity cost 150.000 DH and water 100.000 DH. Altogether 700.000 DH or approximately USD 73.000. If the total semi solid waste was crushed and sent with the waste water through the UASB reactor the amount of methane production could be doubled to an amount of 1.000 m^3 of methane per day. This more or less corresponds to the total need for fuel oil in the plant. Furthermore the waste water that has passed the UASB reactor could be reused in the process. It is, however, clear that any investment with a pay back time of more than 2 years is not likely to be done in this sector. A successful demonstration project will be needed to convince the fish industry in Marocco to invest in an anaerobic cleaning solution (UASB reactor). In the following chapter a specific project proposal has been made how this could be done.

5.3 Olive Oil Industry

In Morocco the olive oil industry is an important industry. There are around 170 specialized industrial units out of which 150 produce olive oil. The other 20 are so called mixed industries that produce both olive oil and olives for direct consumption (olive de table). Besides the industrial units there are a large number, about 16 thousand, small local units where olive oil is produced using traditional methods. The production of olives normally takes place from mid October to mid March. After the olives have been harvested they are normally treated directly upon arrival at the olive mill or conserved before the treatment. As olives have the tendency of becoming rancid, the olives that are not processed the same day, are treated with salt, in order to conserve them. There are basically two ways in which the olives can be processed. The industrial process uses a centrifuge in a two-step process. The more traditional one uses a process where the olive oil is pressed out of the olives.

The olive industry

Types of unit	Number	Capacity (quantity)	Oil production	Waste	
				type	Estimated quantities
Industrial and semi industrial Traditionally (MAASRAS)	170 out of which: 150 specialized & 20 mixed (oil and olives de table)	201635 } tonnes } } } 84800 }	50.000 tonnes (1991/92)	- Wood-pieces - Grignons - Margines	1,1 million t/y 162750 t/y 465.000 m^3/y

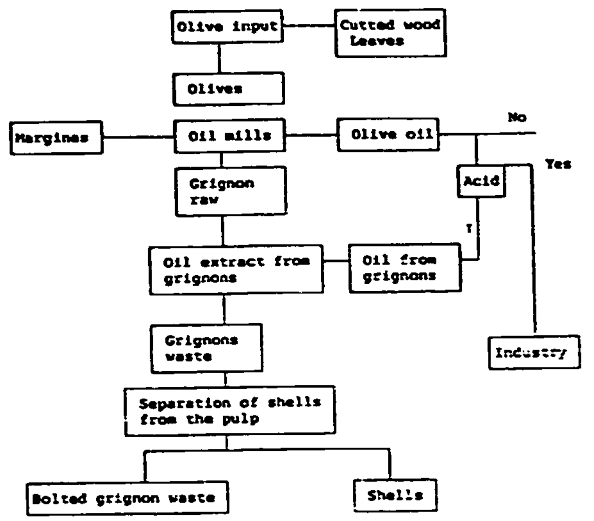
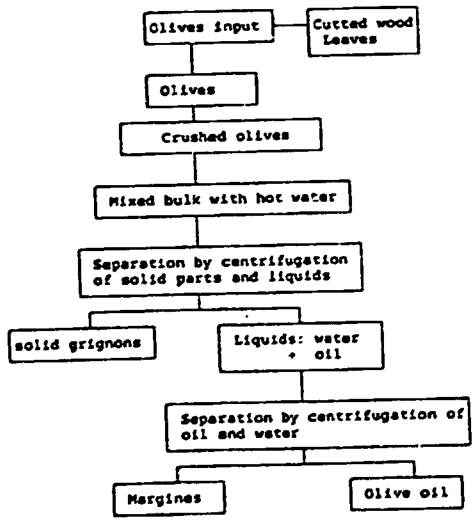


Diagramme showing the traditonal extraction from olives and other subproducts



Procedure to obtain olive oil by centrifugation of different subproducts

In both cases there are three types of waste. Firstly wood and leaves that can be used for burning. Secondly grignon that can be used either as a combustable or as feed-stuff for the cattle or is simply dumped nearby. The important waste, the most polluting waste, is the margin. One can calculate, based on the harvest of olives in Morocco, that around 465.000 m^3 of margin is produced each year. The margin has a very high BOD, around 80.000 milligrammes per litre. As this waste water ends up in the rivers nearby or pollute the ground water is it clear that this is a major polluting factor in olive regions in Morocco. For instance in the region of Fes where 7.000 tonnes of olive oil are produced each year, the pollution from the olive oil plants more or less corresponds to the pollution from a city with 200.000 inhabitants.

At the moment no treatment of the waste water is carried out. Several studies have been made with suggestions of how to treat this waste water. One of the problems with this waste water is a very high COD but there is also some acid in the margin e.g. polyphenol. This prevents a biodegradation process. Tunisia has the same problem with waste from the olive oil mills and here several methods have been tested.

Also in Tunisia in Sfax, tests have been made in order to find out if it is possible to evaporate the margin and thereby make a concentrate that can be dumped or burned. Another test has been done simply by drying the margin at the olive oil mills. During the harvest period a stock of the oil is made. The margin from here is is send to big basins that are placed in the neigbourhood of the heating system, which dries the margin. This process is of course possible but requires very big basins near the industrial units as well as personnel to remove the solid margin.

In Tunisia a mixed aerobic and anaerobic treatment methods have been tested in order to make it possible to reduce the COD with about 95 %. This method is interesting for the industrial units. It has, however, been reported that the process is a bit complicated to run in practise. At the present a BRITE-EURAM project is being carried out together with Greek olive industries, in order to test a flexible process whereby codigestion of olive oil waste together with another type of waste is possible. The aim of this process is to have a fairly simple anaerobic digestion using, for instance, slaughterhouse waste together with olive oil waste. It is recommended to focus on these possibilities whereby a relatively cheap and efficient treatment will be obtained for several industries. Using two types of waste or several types of waste can eliminate the acid effect of the margin. In the paragraph below a specific suggestion is given on how to formulate a project in Morocco in this area. It is, however, clear that such a project can be optimized by using the experience from Greece and Tunisia and to a strenghtening of the technological capabilities in Morocco will be needed in order to produce the best possible solution for the Morocan industry.

6. Infrastructure for Managing Biogas projects

Until now the biogas programme in Morocco has been based on Chinese technology and on German technical assistance. Since 1983 around 350 small Chinese digesters (mainly 10 m^3 digesters and one 180 m^3 system at an agricultural cooperative)[3] and twenty Borda type digestors[4] have been installed in rural areas, the latter digestors ranging in size from 10 to 100 m^3.

[3] The project CDER/MARA/MII/UNICEF "La production de biogaz, la lutte contre la deforstation et l'assainissement des dechets animaux.

[4] The GTZ/CDER/ORMVA "Programme de diffusion du biogaz a Souss-Massa.

Whereas the installation of Chinese biodigesters has stopped, the GTZ continues to cofinance biogas projects under its "Programme Speciale Energie" which began its biogas activities in 1988. The national counterpart organisations are CDER - "Centre de Developement des Energies Renouve lable" and ORMVA.SM - "Office de Mise en Valeur Agricole de Sous Massa". The GTZ biogas programme is focused on the development and the promotion of family unit biogas systems in rural areas. The three objectives are:

- to cover the household's energy demand for cooking by biogas thereby replacing the use of fuelwood and of LPG in households
- to improve the hygienic conditions of manure handling
- to improve the quality of the manure as a fertilizer

The GTZ programme had foreseen to install one biodigester at a slaughterhouse, but for various reasons this activitiy was never initiated[5]. Thus, although the GTZ programme does not discard the agro-industrial sector as a possible target for intervention, the national strategy for biogas development adopted in May 1993 continues to concentrate on the farms.

6.1 Public organization involved in the Biogas Development

The Ministry of Agriculture plays an active role in the area of biogas development in Morocco. This involvement dates back to the introduction of the first biogas digesters. These were implemented in the rural zones and formed an integrated part of agricultural programmes making it possible for the farmers to produce their own fertilizers besides having biogas for heating and cooking. The ministrys interest in the area of biogas development in the agro-industry sector is also quite natural since processing of the agricultural products take place here and fertilizer for the farmers can be produced as part of an anaerobic fermentation of waste from the agricultural sectors.

However, in the agro-industrial sector the Ministry of Industry also has a key-role to play since some of the major plants e.g. the sugar industries are

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[5] Mainly because of the bankruptcy of the German company which was to provide the equipment.

state owned and they are referring to the Ministry of Industry. The involvement of the Ministry of Environment is important since biogas production can help to solve many of the questions relating to environmental pollution from industries, municipalities and the rural areas. Also the Ministry of Energy, which has the responsiblity for the development of renewable energy, is quite interested in the biogas field since biogas is one of the alternative forms of energy that can be used both for heating and for production of electricity.

The combined interest of all these authorities should form a very good background for further involvement in the biogas sector. In order to coordinate the interest it is suggested that a committee is formed with representation from the above mentioned ministries where each ministry contributes to the implementation of a joint biogas programme and some coodination of the activities takes place on a practical level. Also information about new initiatives and the international possibilities in this area.

6.2 Education and technological transfer

Biogas technology and courses in anaerobic digestions are not today a major part of any university programme in Morocco. Universities exist in Rabat, Casablanca, Oujda. Kinitra, Fes, Meknes, Marrakech and Agadir. All these universities have a faculty of Science, and several of these have an education in microbiology. The institution in Morocco that has the most developed education in biogas technology and fermentation technology is Institut Agronomique et Veterinaire Hassan II. This university has 2.200 students and 350 professors. The institute in divided in several sections with a total of 35 departments. In the section of food and agriculture industries, the departments for microbiology, technology, bio-chemistry, nutrition and industrial food processing are to be found. They have a small fermentation lab and they are generally involved in projects relating to how to use and improve the waste from the agro-industrial sector. The department gives training up to the master degree. Considerations are made for the moment if it is possible to etablish an Ph.D. education in this area. The department and this section of the university have facilities and buildings where demonstration units logically could be located.

6.3 Recommendations

In order to implement projects in the bigoas area in Morocco it is necessary to make a strategy of how to optimize the use of the resources. The following points should be a part over an overall strategy:

1. Establishment of a committee with representative from the various ministries with interest in the biogas sector

2. Formulation of country programme based on a number of demonstration projects in the various sectors and where the three enclosed projects could be a part

3. Establishment of financial means in order to make such a demonstration programme possible including specific arrangements with potential international donors regarding allocation of funds for specific projects

4. Formulation of an education and technological transfer programme based on a unversity centre in Morocco

This strategy should make it possible to implement a biogas programme that is taking the local possibilities into account. If the present trend is followed one could fear that each sector has its own programme and money could sometimes be spent on not too well tested foreign technology. Having few national resources to evaluate possibilities and no national demonstration in several sectors it naturally gives a very weak background for the ministries, industries and municipalities when they are chosing various technologies in the different sectors. It is therefore important that any major programme is linked to an educational and technological transfer programme. The specific objectives of this could be:

1. To test whether anaerobic degradability of various types of solid and liquid waste can be predicted based upon hydro-carbons, lipids and protein content of the individual type waste

2. To develop an appropriate mathematical models that can be used for the biogas process simulation and design

3. To compare performance of key digester types with time varying sources of waste as far as stability of operation and efficiency

4. To develop proto-types for optimal handling of mixes sources of waste

5. To access the by-product value as far as water reuse, fertilizer and biogas utilization

6. To develop software packages that will involve optimal configuration and scheduling for single industries with time varying feed charateristics.

7. Persons contacted

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