LIFE Project Number

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FULL PROJECT TITLE

‘Design and Application of an Innovative Composting Unit for the Effective Treatment of Sludge and other Biodegradable Organic Waste in Morocco, MOROCOMP’

Task 5:

Alternative uses of compost – Market opportunities in Morocco

Deliverable 17A

Market of Compost produced from Sludge and other biodegradable organic waste in Morocco

composting MOROCOMP

April 2008

FOREWORD

This study is carried out within the framework of project MOROCOMP (Life 05TCY/MA/000141): Design and installation of an innovative composting unit for the effective treatment of sludge and other biodegradable organic waste in Morocco. The project beneficiary is the University Chouaib Doukkali in partnership with the National Technical University of Athens and the Regional Office of Agricultural Development of Doukkala.

An innovative composting system was set up for the treatment of sludge produced by the urban wastewater treatment plants and other biodegradable organic waste (BOW) in Morocco. This project will allow the operators and the national authorities to treat, manage and reuse sludge and any other Biodegradable Organic Waste effectively and in compliance with the European environmental policy. It contributes to the safeguarding of the ground water resources of Morocco from the uncontrolled disposal of untreated sludge, thus supporting the protection of public health and the environment.

At the same time, the use of treated sludge and other BOW as amendment of soil will reduce the use of synthetic fertilizers and will contribute to the protection of arable lands against degradation. It will also make it possible to preserve underground and surface water from contamination. This system of composting could be used for other applications to the level of wastewater treatment plants on a large scale. The unit installed in Zemamra, within the framework of the MOROCOMP project, will be used as a pilot of demonstration in Morocco and in European geographical sectors which have the same characteristics and face similar problems.

Within the framework of this project several activities were carried out, in particular:

- Assessment of the existing situation in the European Union and in Morocco regarding sludge and other BOW generation and management (treatment, reuse and disposal), as well as assessement of the related legislation
- Review of composting practices in the European Union and internationally (review of best practices and success stories)
- Design and construction of an innovative sludge and other BOW aerobic composting system, based on the characteristics and needs of Morocco
- Development of sludge and other BOW aerobic composting process – Optimization of the operation of the demonstration composting system
- Use of alternative additives of Mediterranean origin incorporated into the composting process, as well as co-composting of sludge and other BOW. Determination of the most efficient compost mixture
- Evaluation of the compost products as soil improvers in laboratory and open field applications
- Development of specifications and guidelines covering the area of sludge and other BOW composting, characterization and use of compost as soil improver in large scale
- Examination of alternative uses of the end products
- Assessment of compost market and jobs opportunities in Morocco

- Dissemination of the project progress and results (trips, conferences, workshops, meetings, website, printed material, etc)
- Training of the staff of the competent authorities and personnel that shall be involved in the compost production and distribution
- Public information and participation
- Management of the project and reporting to the EC

The results of the project have contributed to:

- Development of know-how for the efficient management of sludge and other BOW in Morocco
- Development of instruments for the competent authorities in order to design and apply appropriate schemes for the management of sludge and other BOW
- Autarchy in the technology means for the management of sludge and other BOW
- Reduction of the use of chemical fertilizers and protection of sensitive water bodies from eutrophication
- Well-trained staff that can be involved in the development of the technology under examination
- Adoption of the priorities of the EU concerning the recovery and reuse of materials
- Convergence towards the existing EU legislative framework and environmental policy concerning the management of sludge and other BOW
- Solving out the problem of the disposal of sludge and other BOW
- Promotion of sustainable agricultural practices
- Utilization of Meditteranean minerals like bentonite, zeolites and perlite as additives
- Production of compost materials that can be used as soil improvers

The objective of this study is to show the possibilities of marketing of compost in Morocco starting from the data collected on the quality of the soil, the needs for national agriculture in organic manure and several alternative uses. This study takes into account the current and future availability of raw materials for composting (sludge and organic waste biodegradable) and the quality of the produced compost and its conformity with the national and European legislation.

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Part 1: DIAGNOSTICS AND ESTIMATE OF THE REQUIREMENTS IN ORGANIC MATTER FOR THE AGRICULTURE IN MOROCCO

PROBLEMS OF THE SOILS IN MOROCCO

I General information

The total surface area of Morocco is about 712.550 km^2. The useful agricultural surface covers approximately 9 million hectares, which is approximately 12,6 % of the total surface area of the country, including 1,3 million hectares in the irrigated perimeters. The potential irrigable ground surfaces amount to 1.664.000 ha including 1.364.000 ha of perennial irrigation and 300.000 ha of seasonal irrigation and of spreading of water wells. The surface areas managed in a modern or traditional way for the perennial irrigation rose, at the end of 2004, to 1.458.160 ha including 1.016.730 ha managed by public authorities and 441.430 ha by private authorities.

Based on the differences in climate, the Moroccan soils can be classified in to two broad categories: those of the humid or semi humid area of the Atlantic region in the north-western part of the country, and those of the arid or semi-arid areas of south-east.

In the rainy areas, the dominant soils are the soils under grassy vegetation which have a restricted surface area. The prevailing parts of the soils are the chestnut soils and the tropical black clays. Most of the soils are formed under forest vegetation and show consequently marks of scrubbing (washing). The large parts represented are the brown soils, the washed soils, the yellow-red soils and the gray forest soils. In spite of the scrubbing which occurred during the centuries, the majority of the soils are still of limestone. Most of the Rifain Atlas is acidic. Other areas are found on acidic surfaces (pH 6,0-6,5) in the forest of Maâmora close to Rabat, in most of the sandy coastal plains in the north of Casablanca, in the regions of Larache and Khémisset, and in certain parts of the plain of Chaouia in the south-east of Casablanca. Erosion, both geological and agricultural, occurred in the flooding plains along almost all the streams and rivers. The best known alluvial plain is that of the Sebou Wadi, usually called the plain of Rharb. Many of the grounds of this plain are alkaline.

In Morocco, six agro-ecological areas are distinguished, characterized by their climate, their topography, their specificities in terms of natural resources and the systems of production. These agro-ecological conditions allow a diversification of the cultivations. The distribution of these zones is presented in Table 1. The majority of **the favourable zones** is located in the north-western part of the country characterized by average precipitations exceeding 400 mm. The farming system in this zone is composed of 60% cereal (including wheat 77%), of 10% of truck farming, 12% of elevated cultivations and 15% of fallow. The remaining cultivations (3%) is composed of sunflower and fodder crops. **The intermediate zone** is located in the central plain (Chaouia – Doukkala) and its average precipitations vary between 300 and 400 mm. The farming system in this zone is composed of cereal 75% (including barley 40% and 11% of corn) and 22% of fallow. The garden and elevated cultivations account for 2,3% and 0,7% respectively. The **unfavourable zones of the south and of the east** of the country average precipitations, lower than 300 mm. These zones are characterized by the deterioration of their soils because of the erosion generated by the strong winds and the rains. They are also marked by the importance of the fallow. As a principal source of food for the cattle, the barley accounts for 53% and 78% of cereals respectively in the south and the North-East of Morocco. There is also 10% of corn in the southern coastal zone. **The mountainous zone** is characterized by

relatively high average precipitations (400 mm). The farming system in this zone is dominated by the cereals (62% with wheat 60%). Fallow and arboriculture account for 33% and 4% respectively. **The Saharan zone** is characterized by a low average of precipitation (less than 150 mm) and it is not appropriate for rain cultivations. The principal agricultural activity is the agriculture of the oases and the breeding of the camels.

Table 1: Characteristics of the agro-ecological areas in Morocco

Zones	Precipitations (mm)	Normal average of precipitations (mm)	Arable land (x1000 ha)	Proportion of arable land in %	Cultivations in %
Favourable	> 400	565	2610	30	Cereal 60% (77% wheat)
Intermediary	300-400	347	2088	24	Cereal 75% (40% barley and 11% corn) and 22% fallow
Unfavourable South	200-300	320	1044	12	Cereal (including 53% barley) and Fallows
Unfavourable East (Eastern)	200-300	248	1044	12	Cereal (78% barley) and Fallows
Mountainous	400-1000	510	1305	15	Cereal 62% (60% wheat); 33% fallow; Elevated cultivations 4%.
Saharan	< 150	113	609	7	Agriculture of the oases.

II. Degradation of the soils in Morocco

The apparent forms of degradation of the soils following the agricultural use are numerous:

- degradation (biological, Organic, mineral);
- destruction of structures and settlements which affect porosities;
- erosion, sedimentation, landslides;
- salinisation and alkalisation;
- acidification;
- pollution (mineral, organic, radioactive).

These modifications have as consequences:

- reduction in the fertility of the soils;
- the loss of their fundamental functions;
- the deceleration of the speed of the fabrication of the soils;
- modification of the speed and of the orientation of the principal processes of formation and differentiation of the soils (deterioration of the rocks, arrangement and movements of the components).

Consequently, each year, several tens of thousands of hectares, often very fertile, are irreversibly lost. The human activities undermine the biodiversity on soils which changes. Also the water cycle becomes more violent (risings, floods, sedimentations downstream), water is still less available for the human needs, the quality of water is inferior and is polluted, chemically and biologically Locally and laterally water is even less available for the human needs. Many areas e are impoverished, even abandoned (turning into a desert); but there are also environments which grow rich, thanks to human activities.

Even if the inventory work and the soil mapping in Morocco covers only approximately 30 % of the territory, the main thing of what the soils of Morocco are, is known, in particular their qualities and defects and the attacks which they undergo because of the intensification of the human occupation. Thus an degradation of the irrigated soils (1,4 million ha) is noted, expressed by the fall of the content in organic matter, the collapse of the structure, the chemical fall of fertility and the salinisation. In general, there is a progressive fall of the agricultural productivity.

1. Degradation of the soil in non-irrigated zone

The degradation of the non-irrigated soils which covers the main part of the useful agricultural surface of the country (approximately 7,7 million ha) has as a result (1) the reduction of the incorporated organic matter, (2) the development of hydrous and wind erosion, (3) the reduction of the water holding capacity and (3) the reduction of the useful water reserve of the soils .

2. Degradation of the soils under irrigation and losses in organic matter

In the irrigated perimeters the reduction of the content in organic matter is a typical phenomenon. This reduction is caused by the bad management of the residues of crop products, the low use of manure and compost and by the rapid mineralisation of the organic compounds. The content in organic matter of these soils is generally lower than 1,5 % whereas the reduction rate observed is about 6% to 10 % per year.

The analysis of the fertility of the soils in the irrigated perimeter of Doukkala made it possible to emphasize the tendency of the organic matter reduction rate in the principal types of soils over a 10 year period (table 2). The average decimal loss of organic matter (over 10 years) through the four principal soil types in Doukkala varies from 18,1% to 32,6%. **The losses proved higher in the sandy soils and in the not very advanced soils**. This can be explained by the low fraction of clay which is likely to guarantee a relative protection of the organic matter in association between argillaceous mineral colloids and humic colloids. The low rates of loss are observed for the clay soils.

The annual rates of organic matter loss by mineralisation in Doukkala vary from 1,9% to 3,3%. These values make it possible to quantify the fresh organic matter which would have been restored to the soil to avoid the losses observed.

Table 2: Evolution of the content of organic matter in the principal types of grounds

Type of soil	Soil in %	Organic matter in %			Average Decimal Loss (%)
		1987a	1993b	1997c	
Vertisol (Tirs) *	52	1,99	1,50	1,22	21,7
Isohumic (Hamri)	16	2,48	1,47	1,11	32,6
Fersiallitique	15	1,84	1,02	0,85	30,7
Not very advanced (Faïd)	17	1,53	1,35	1,02	18,1

* the names between brackets means local names. a: SASMA 1987. Study of diagnosis of the fertility of the soils of Doukkala. b: Badraoui and Bouaziz (1993). Diagnosis of the fertility of the soils in Doukkala (Project MAMVA/ORMVAD). C: ORMVAD (1997). Diagnosis carried out by the ORMVAD.

In spite of the bonds between the organic matter and certain intrinsic properties of the soil, such as its content of clay, the farming history and the agricultural degree of intensification have more

marked effects on the dynamics of the organic matter. This can be illustrated in table 3 relating the data of analyses of some dynamic components of the organic matter. When one compares the isohumic soils of Chaouia having vertic character (IVC) and that of isohumic Tadla having vertic character (IVT), which are genetically identical, it is noted that the one of Tadla is lower in organic matter and nitrogen. This is attributed to the intensive development which is not accompanied by an adequate management of the residues of the cultivations. Indeed, in the majority of the irrigated perimeters, and particularly Tadla and Doukkala , the residues of harvests are generally exported parcels. Moreover, the temperature and the irrigation ensure optimum thermal and hydrous conditions for mineralisation. This phenomenon is amplified by frequent soil works which increases the accessibility of the organic matter to bio-degradation.

Table 3: Comparison of some dynamic parameters of the organic matter enters an area of rain agriculture (Chaouia) and an irrigated perimeter subjected to an agricultural intensification (Tadla) (Soudi, 1989, 1990)

Parameters	**Soil IVT [1] (0 – 10 cm) Tadla**	**Soil IVC [2] (0 – 11 cm) Chaouia**
N-org (g/kg)	1,4	2,2
C-org (g/kg)	13,0	23,3
N-hydrolysable (mg/kg)	915,6	1192,0
N-amino Total (mg/kg)	428,8	503,4
Fixed ammonium (mg/kg)	71,3	120,8

IVT [1] : isohumic soil with vertic character in the perimeter of Tadla.
IVC [2] : isohumic soil with vertic character in Chaouia.

This comparison confirms that the type of the soil cannot only in itself explain the tendencies of evolution of the organic matter and that the degree of intensification and the mode of exploitation of the soil have a considerable impact.

3 Conclusion

The soils in Morocco show a very strong degradation, especially a considerable loss in organic matter which is what threatens the durability of the systems of agricultural production in the country. The requirements in organic matter, in order to maintain a durable productivity, are evaluated in part 2.

PRINCIPAL CULTIVATIONS IN MOROCCO

Moroccan agriculture is dominated by cereals which occupy 63% of the total of the arable land, followed by arboriculture with 8%, truck farming 2%, fodder crops 2%, industrial crops 3% and leguminous cultures 4%, the rest being fallows (table 4). The majority of the cultivation of cereals, leguminous plants and fodder crops is led by rain agriculture and the levels of the production are determined by the importance and the distribution of annual precipitations.

Table 4: Use of the arable lands in Morocco (RGA/MADRPM. 1997/98)

Cultures	Surface (x1000ha)	Surface in %
Arboriculture	696	8
Cereals	5481	63
Fodder crops	174	2
Industrial crops	261	3
Fallows	1566	18
Leguminous plants	348	4
Truck farming	174	2
Total	8700	100

Table 5 shows that the mean level of the output obtained is still low and that in the future the agricultural practices in Morocco will remain dependant on irrigation, in particular for the cultivations hereafter:

- sugar beet and sugar canes which account for 60% of the demand for sugar;
- truck farming intended for export (tomato, onion, etc.);
- citrus fruits (Morocco is the seventh world exporter);
- exotic products, fruits and cut flowers (introduced recently into export);
- cereals (auxiliary irrigation).
-

The consumption of manure in Morocco varies from one culture to another, thus, approximately 32% of the manure is used by citrus fruits, sugar cultures and the market garden crops which occupy only 5% of the acreage and which are grown primarily through irrigation. As for the cereal cultures, which occupy 63% of the acreage, they mobilize only approximately 43% of the global tonnage.

The output of the cultures is closely linked to the consumption in manure. According to table 6, the most demanding cultures in fertilizing elements are beet roots, the market garden crops and the fruit-bearing plantations. Their output is closely linked to the contribution in manure.

Table 5: Surface, production and output of the principal cultures (Average of the five last crop years) (MADRPM/DPV, 2003/04)

Cultures	Surface (x1000ha)	Production (x1000 tons)	Output (Tons/ha)
Citrus fruits	76	1300	17,0
Sugar beet	61	3100	52,3
Cereals	5000	4300	0,9
Cultures fo urragères	360	130	-
Broad bean	190	152	0,8

Lens	70	35	0,5
Corn	300	240	0,8
Truck farming	232	5000	-
Olivier	548	500	0,9
Date palm	48	59	-
Peas	50	25	0,5
Chickpeas	70	49	0,7
Potato	56	1200	17,0
Rosacées	194	570	-
Sunflower	70	55	0,8
Vine	50	310	6,2

Table 6: Correlation between manure consumption and culture output (IAV Hassan II, 2001)

Product	Cereal	Leguminous plants	Beet	Cane with sugar	Oleaginous cultures	Market gardenings	Fruit-bearing plantations
N	0,33	0,18	0,85	-0,33	0,02	0,68	0,71
P_2O_5	0,04	0,09	0,43	-0,46	0,04	0,52	0,65
K_2O	0,24	0,12	0,69	-0,56	-0,03	0,61	0,67
All	0,26	0,17	0,79	-0,46	0,02	0,70	0,78

The coefficient of correlation is significant to 0, **4êt with $\alpha = 0,05$**

MANURES IN MOROCCO

Optimal fertilization supports optimal output while maximizing profitability of the cultures. It also contributes to maintain the balance of the fertility of the soil and to avoid the appearance of various farming problems, such as deficiencies or the excessive growth of bad grasses. Avoiding excessive use of fertilizers makes also possible the reduction of risks of water contamination by the nutritive elements, in particular nitrogen and phosphorus.

Although mineral fertilizers had relatively little use in agricultural practices in Morocco, in recent years they have shown a rather notable progress. However, their use proves to be advantageous only if it is justified by data on soil fertility and on the contribution in fertilizing elements of the manure, the residues of cultivations and other sources of organic matter. On one hand, on very poor soils, it is sometimes advantageous to add to the soil as much as possible nitrogen, phosphorus and potassium which are taken by the cultivations. On the other hand, addition of fertilizers in fertile soils, does not provide additional profits but it may have a negative impact to the cultivations and to the environment.

Mineral manures are mostly manures of which nutritive elements, mainly nitrogen, phosphorus and potassium, are very soluble and quickly available to the plant. These manures are more concentrated than farm manures (or organic manures) and consist of only one fertilizing element (simple manures) or of several elements (composite manures).

The quantity of manure applied on land is always moderate: in field crops, it varies from 100 to 500 kg per hectare, according to the richness of the manure considered and the cultivation type.

In truck farming manure application can reach up to 1 ton per hectare and sometimes even more.

Organic manures are different from mineral manures by their origin: they consist of matter which has its origin in living beings. The distinction between organic soil conditioners (manure, liquid manure, green manures, crop waste products) and organic manures remains rather theoretical. One can however say that organic manures are more concentrated and richer in nitrogen than the amendments.

The fertilization of the cultivations is very much dependant on the mineral fertilization and the use of manure, , the residues of cultivations etc. Tables 7 and 8 present a comparison between the two approaches.

Table 7: Comparison of farm manures with mineral manures.

Manure of farm (manure, green manures, residues of cultures…)	**Mineral manures**
- Bring to the plants major and minor nutritive elements in variable proportion depending on the availability in time. - Bring a considerable quantity of organic matter. - Contribute to maintain a good structure of soil and consequently the fertility of the soil.	- Bring to the plants immediately assimilable nutritive elements, allowing a fast startup of the culture. - do not bring any organic matter to the soil - Can modify the natural balance of the micro-organisms of the soil. - Use of nonrenewable resources for the manufacture of the synthetic products

Table 8: Comparison of the organic soil conditioners to the inorganic soil conditioners.

Organic soil conditioners	**Inorganic soil conditioners**
- Increase gradually the quantity and the organic quality of matter. - Improve the capacity of the soil to retain water, which is very useful in period of dryness. - Release gradually nutritive elements (nitrogen, potassium, phosphorus, manganese, etc). - Support the growth of plants by improving ventilation and cohesion of the soil. - Improve the infiltration of water in the soil and consequently decrease the risk of streaming.	- Allow the plants to better absorb the nutritive elements by correcting certain physico-chemical properties of the soil (e.g.: agricultural lime).

According to research characteristics, manures and mineral soil amendments can be complementary to farm manure and organic soil conditioners.

I – Use of manures in Morocco

The demographic growth and the will to improve the standard of living in the rural environment require the increase in the productivity of agriculture in Morocco. This can be done only through the improvement of the control of the cultivations by adopting powerful farming techniques. The manure constitutes a principal pillar, making it possible to have appreciable profits in productivity. The analysis of the current situation in terms of the use of manures shows an under-use compared to the needs and a low rationalization for fertilization. The number of farms which have used manures, amounts to 732.550, that is 51,2% of the farms and the ratio of

utilization increases with the size of the agricultural exploitation. The contribution in nutritive elements is currently only 45 fertilizing units per hectare, covering 33% of the needs. The low level of use of manure results not only by a loss in output, but also by a continuous degradation of the Moroccan soils in nutritive elements. This situation is in particular related to the increase in the cost of the manure which is not compensated by the change in production prices. In addition to the agronomic disadvantages (drop in productivity, increase in costs), the irrational use of mineral manures can have, in the long term, adverse effects on the natural environment and measures need to be taken for the use of.

1 - Use of mineral manures

1.1- Nitrate fertilizers

The consumption of nitrogen has evolved rapidly since 1979/80, when it was 87.415 tons, to 1985/86 when it reached 136.582 tons. This is probably linked to the popularization and to the subsidy of manures. It evolved less rapidly during the period 1985/86 to 1993/94. This can be explained by the suppression of subsidies, the increase in prices and the dryness which occurred at the beginning of the nineties. This consumption then showed fluctuations where several factors intervened. It is currently of the order of 224.722 tons and it constitutes 56% to 57% percent of the total Fertilizing Units consumed.

Among the nitrate fertilizers used in Morocco, ammonium nitrate is the one consumed more with 27%, followed by urea with 17%. Ammonium sulphate is the less consumed nitrogenous product. The 14-28-14 ternary manure, which is the basic principal manure, contributes 15% in the consumption of nitrogen.

1. 2 Phosphate-enriched fertilizers

Phosphate consumption has increased slightly since 1979/80, when it was 67.158 tons, to 116.590 tons in 1989/90. Significant fluctuations emerged, in particular, reductions linked to the increase in prices. Consumption is currently about 117.000 tons of P_2O_5, which constitutes 29,5% of the overall consumption of UF.

1.3- Potassium Manure

Potassium is the less consumed nutritive element in Morocco. The consumption recorded in 1979-80 was 36.776 tons and it is currently about 55.000 tons of K_2O. It constitutes 14,5% of the overall consumption of Fertilizing Units. Potassium chloride is consumed less since its use is not recommended because of its salinity effect. In spite of the high content, in K_2O of potassium sulphate, the contribution coming from the 14-28-14 is superior, because it is the most sought after by the farmers. Potassium sulphate is used primarily in industrial and horticultural crops of high profitability.

2 Use of mineral manures in irrigated and non irrigated zones

The analysis of the consumption of manures, according to agricultural zones, shows that approximately 58% of capacity is used at the level of the irrigated zones, against 42% use in non irrigated zones (depended on rain). The total surface areas, devoted to each culture and the

fertilized part of the surface areas, irrigated and non-irrigated, respectively, are presented in table 9.

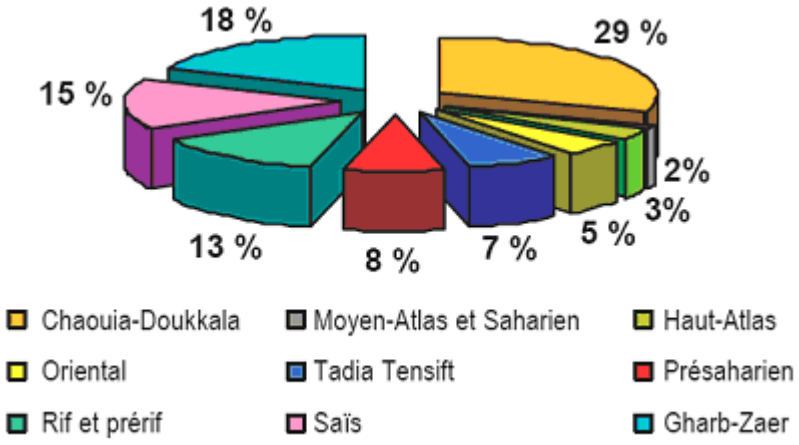
Table 9: Areas cultivated and fertilized proportions, irrigated and non-irrigated

Culture	Surface x1000 ha	Surface F ertilized in %	
		Non-irrigated	Irrigated
Cereals	5000	20	90
Leguminous plants	380	20	90
Fodder	360	50	100
Citrus fruits	76	-	100
Rosacées	194	40	80
Olive Trees	548	30	60
Vine	50	60	100
Truck farming green house	23	-	100
Truck farming field	209	80	90
Date palm	48	-	10
Sunflower	70	100	-
Sugar beet	61	-	100
Potato	60	-	100

3 Use of mineral manures by area

The analysis of the distribution of the consumption of manure per agricultural zone emphasizes that consumption is concentrated in particular in the north western of Morocco, in fact to the zones of Chaouia-Doukkala, Gharb-Zaer, Saïs and Rif and Pre-Rif. The percentage of distribution is presented in figure 1.

Figure 1: Distribution of manures of Morocco



The actual mean level of manure utilization is 398.000 tons Fertilizing Units. This quantity hardly represents one third of the needs for agriculture which are estimated at 1,2 million tons of Fertilizing Units. This low level of use results in a continuous degradation of the Moroccan soils in nutritive elements.

The recorded fluctuations are linked with the variations of the consumption of manure since the useful agricultural surface is almost stagnated. Consumption in N/ha and P_2O_5 / ha shows the same fluctuations as the overall consumption, whereas the consumption of K_2O/ha is about

stable. Indeed, the contributions in fertilizing elements per hectare do not actually exceed 45 Fertilizing Units, i.e. 33% of the needs, which are of the order of 138 Fertilizing Units.

II Use of the organic manure

The organic manures used in Morocco are mainly manure coming from bovine, sheep and goat and horses. Peat is used not as organic manure but rather like support for starting certain cultures in truck farming or arboriculture. Green manures are used only in a very limited number of farming cultivations. The compost misses quasi national market and its use is limited to certain seedbeds.

Manure consists of a mixture of litter and waste having undergone fermentation, pushed more or less with the cattle shed or in a pile. The average composition of manure is variable depending on the animals, the nature of the litter, the proportion of straw and waste, the food and the degree of decomposition of manure.

The characteristics and the dose of use of manure from bovines and manure from sheep are presented in table 10 (Chafia, 2003). The recommended dose can be reduced according to availability. Manure is applied, especially in cereal cultivations and crop gardening. In addition, certain attempts at composting by industry have been noted. These actions are timid but they will have a significant future with the development of biological gardening crops.

Table 10: Composition of the manure of the sheep and the bovines according to Chafia El Alaoui, 2003.

	Manure of sheep	**Manure of bovines**
Material	**Thousands**	
Organic matter (dry)	280 to 320	120 to 170
Humus	100 to 150	50 to 100
Fertilizing elements	**kg/ton of manure**	
Total Nitrogen	8 to 8,5	4 to 5
Phosphorus P_2O_5	2 to 2,4	2,5 to 3
Potassium K_2O	6,5 to 6,8	5 to 6
Calcium		5 to 4,5
Magnesium		0,2 to 1
Annual doses of use	**In ton/ha**	
- at the head of rotation	40 to 50	50 to 60
- in manure of maintenance	20 to 25	24 to 30

*: The mode of contribution is the direct contribution to the soil

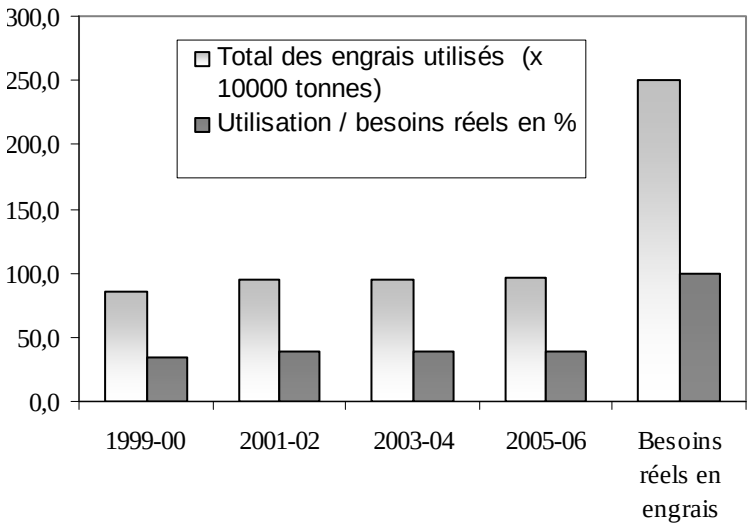
III. Market of manures in Morocco and distribution network

1 Evolution of the global consumption of manure

The evolution of the global consumption of manure during the agricultural seasons of 1990 to 2004 is presented in figure 2. The analysis of the actual situation as regards the use of manure,

shows an under-use compared to the real needs of the country, which rise to approximately **2,5 million tons**. The bottom level of consumption of manures (less than 40% of the real requirements in manure) is explained by the increasingly high climatic risks which the farmers face on one hand, and successive rises in the price of manures on the other. The farmers direct themselves towards the reduction of the level of the investment in imports, in particular at the beginning of the season. The evolution of the consumption of manures during the seasons of 1999 to 2006 is presented in figure 2.

Figure 2: Evolution of the total consumption of manures in Morocco



In Morocco only 51 % of the farms use manures; consequently, the agricultural productivity still remains very low. Disregarding the large fields, which account for 7% of the farms and which practice a peak agriculture, integrating complete solutions of vegetable nutrition, according to needs for their cultures, the major part of the farmers (which represents more than 70%) does not use fertilizers to correct the deficiencies of the soil. Moreover, the quantities used remain on average largely on the side of recommended technical applications. In spite of certain constraints, in fact those related to the financial capacity of the farmers, **there is an extraordinary potential for the development and the intensification of the use of manure**.

2 Market of manures in Morocco

The policy of agricultural development of Morocco is based on the use of rational methods of use of various factors of production. Among these factors, manure, which constitutes a determining element of the productivity, enjoys a privileged place. The country's supply of manure and its marketing have passed from three large phases.

A first period (1956 and 1974), when the supply of manure in the market was characterized by a freedom of imports and a concentration of the distribution in the large urban centres. In this period the State founded a subsidy for the use of these imports, exempted customs taxes for imports and authorized the Office Chérifien des Phosphates (OCP) to supply the country with manure. In 1975, to avoid the instability of the manure market, the state fixed its selling price in Morocco.

Since 1986, a deceleration in the growth of manure consumption was observed, partly following the will of the State to disengage from the cost of manure subsidy, which started to increase following significant increases in the prices of these products.
Since July 1990, and in order to set up a competitive market of manures, supply is completely liberalized. Indeed, the industry can be supplied freely both with local manures as well as imported ones, while addressing the local market or proceeding to imports. However, the sector continues to profit from the exemptions of customs taxes to imports.
Thus, formulas are manufactured by the distributive firms of manure, at the request of their customers, resorting to the physical mixture of manures imported or manufactured locally, with or without additives. As for the imports, they relate mainly to nitrogenous products (urea 46% N, sulphates of ammonia 21% N and ammonium nitrate 33,5% N) and the potassic products (potassium sulphate 48-50% K_2O and potassium chloride 60% K_2O). Other formulas of organic or mineral fertilizers, correctors of deficiencies or growth regulators, are imported, making it possible to provide for certain very limited needs, in particular to the level of the intensive cultures.
In addition, **the marketing of manure is not organized, and the sales are generally done in a non controlled system**. Thus, statistics for sales and selling price are very variable and unofficial.

3 Distribution network of manures

In Morocco, the country's supply with manure is assured mainly by the company FERTIMA (approximately 42%), two average size companies (36%) with an annual average quantity distributed varying from 156.000 to 190.000 tons; three small to average companies (14%) and six small companies (8%).
The local distribution of manures is done through three principal networks:

- Direct sale starting from the factories and depots of the distribution firms. These sales concern to a large majority, big size farms and co-operatives coming either from land reform or from supply. These sales relate also to certain cultivations under contract, such as sugar beet.
- Networks of retailers, who are supplied, starting from the factories and depots of the distribution firms, and then reassigning them to the farmers.
- Network of points of sale, located at the level of the centers of work or centers of agricultural development (regional institutions of the Ministry for agriculture) reporting to the DPA and the ORMVAD, respectively. These points of sale, which constitute the principal source of supply of manure for the small farmers, are mainly supplied by the company FERTIMA.

The analysis of the distribution of the retailers, per region, is presented in table 11. The analysis of the network of marketing of manures emphasizes that the retailers are concentrated mainly in Gharb - Zaer, Chaouia and Doukkala followed by Saïs, The Eastern, Rif and Prérif. The other areas do not have a significant manure retailer network.
This situation is due to the fact that the retailers prefer moving in the irrigated perimeters and in the favorable zones where sales are regular and tend to be stable; it is the case, in particular, of the areas of Agadir, Casablanca, Kénitra-Sidi Kacem, Nador-Berkane, Laarache, El Jadida,

Benslimane, etc. Moreover, it was noted that the development of the agricultural production in irrigated areas, the replacement of the traditional cultivations and the multiplication of the projects integrated in the rural environment, involve the increase in the number of retailers of manure.

Table 11: Distribution of depots and retailers of manures

Area	Number of retailers and depots	%
Saïs	99	10
Chaouia – Doukkala	203	21
Gharb – Zaer	189	19,4
Tadla – Tensift	80	8
Eastern	100	10
Average Atlas	46	5
High Atlas	67	7
Rif and Prérif	123	12,6
Presaharan	66	7
Saharan	1	-
Total	974	100

Source: IAV Hassan II, 2001

On the other hand, the phenomenon of dryness or hydrous stress leading to a reduction in the use of manures, generated the closing of several points of sale of manure, in particular in arid and semi-arid regions (areas of the south, Figuig, Kelaâ Seraghna, Essaouira, Ouarzazate, etc).
The points of sale, 360 in numbers, allow the supply of the remote zones, on one hand, and the regulation of the prices at the local level on the other. However, these points of sale are closed to installations of private retailers.
The list of the principal distributors and retailers of manure in Morocco is presented below:

List of retailers of organic manure in Morocco

Companies of marketing of organic manures in Morocco Agri Trade Morocco
108, data base Ambassador Ben Aïcha, c/o S.c.e. 20300 Casablanca.Morocco
Telephone: +212 22 24 59 00
Fax: +212 22 24 58 85
Agricultural counter of the Seeds (Casem)
road of Azemmour ang. data base Mly Abderrahman, block B 20050 Casablanca. Morocco
Telephone: +212 22 90 43 43
Fax: +212 22 90 32 14
Flowers Fine
41, avenue of the Pleiads. 20100 Casablanca. Morocco
Telephone: +212 22 86 58 76
Fax: +212 22 86 58 76
Agriculturel And Trading Company s.a.r.l. (Atraco s.a.r.l.)
101, street of Saëns Saint, View-point. 20300 Casablanca. Morocco
Telephone: +212 22 40 28 97
Fax: +212 22 24 71 18
S t-piece Of the sherifs of Engr board and Chemicals (S.c.e.)

108, data base Ambassador Ben Aïcha. 20300 Casablanca. Morocco
Telephone: +212 22 24 59 00
Fax: +212 22 24 58 85
Trade and marketing center
90-91 and 93 rte national Ouled Dahou. Agadir. Morocco
Telephone: +212 28 31 92 82
Fax: +212 28 31 92 85
Ercros The Maghreb
10, street Ahmed Lazrak - ex El Farahidi, 1°ét.. 20100 Casablanca. Morocco
Telephone: +212 22 94 04 55
Fax: +212 22 94 14 54
Agro Spray Technic s.a.r.l.
district Takadoum IQ, n°28 batch. 10000 Reduction. Morocco
Telephone: +212 37 63 84 32
Fax: +212 37 63 85 37
Bodor s.a.r.l.
8, street Has Baha - ex Ferdinand Lesseps. 20000 Casablanca. Morocco
Telephone: +212 22 20 02 77
Fax: +212 22 29 67 85
Vita Morocco s.a.
33, street Chaouia - ex Colbert. 20000 Casablanca. Morocco
Telephone: +212 22 27 51 45
Fax: +212 22 29 35 49
Agricultural Materials Company (Agrimatco s.a.)
27, B D Mohamed Zerktouni, 7°ét. 20100 Casablanca. Morocco
Telephone: +212 22 48 76 61
Fax: +212 22 48 76 64
New Garden s.a.r.l
13, data base Al Alaouyine, 2°ét. appt.9. 10000 Reduction. Morocco
Telephone: +212 64 39 50 75
Fax: +212 37 70 53 03
Charaf Corporation (Charaf Corp. s.a.)
130, data base of Anfa, 3°ét. 20000 Casablanca. Morocco
Telephone: +212 22 27 06 87
Fax: +212 22 29 50 56
Ets Chulliat and Lahlou
13, data base Ain Taoujtate - ex Jouffroy. 20 050 Casablanca. Morocco
Telephone: +212 22 36 73 90
Fax: +212 22 48 72 77
Co. of Production and Marketing of Chemicals, Agricultural and Industrial (Promagri)
Sidi Maârouf de Bouskoura. 20190 Casablanca. Morocco
Telephone: +212 22 33 50 54
Fax: +212 22 33 50 75
Company of Chemicals of Morocco (C.p.c.m.)
data base Oukat Badi, Rocks Blacks. 20300 Casablanca. Morocco
Telephone: +212 22 40 20 70
Telephone: +212 22 40 20 71
Fax: +212 22 24 83 44
Promo Parts s.a.r.l.
129, street of Lieutenant Mahroud Mohamed. 20300 Casablanca. Morocco
Telephone: +212 22 40 10 03
Fax: +212 22 40 10 06
Agricultural counter of Souss
industrial park, rte of Biougra. 80150 Aït Melloul. Morocco
Telephone: +212 28 24 74 10
Fax: +212 28 24 74 15
Bioda Morocco s.a.r.l.
169, batch Yasmina I. Aït Melloul. Morocco
Telephone: +212 28 24 09 94
Fax: +212 28 24 00 92

The World of the Garden
57, street Abou Al Alaa Zahar - ex Vésale, district of the Hospitals. 20100 Casablanca. Morocco
Telephone: +212 22 86 09 03
Fax: +212 22 86 01 20
Process
Machine Anza. 80000 Agadir. Morocco
Telephone: +212 28 20 40 02
Fax: +212 28 24 74 15
Seedbed Vegetable Universe
1, street Baghdad. 20800 Mohammedia. Morocco
Telephone: +212 23 32 59 76
Fax: +212 23 32 50 70
Gallia Industries s.a.
street Al Adarissa, z.i. Berrechid. Morocco
Telephone: +212 22 32 43 73
Fax: +212 22 32 56 26
Timac Agri Morocco
290, data base Mohamed Zerktouni. 20000 Casablanca. Morocco
Telephone: +212 22 26 50 38
Fax: +212 22 48 14 52
Co. Agricultural of Fertilizers Maro C (Agrifertil s.a.r.l.)
industrial park, batch. 158. 24000 El Jadida. Morocco
Telephone: +212 23 37 01 94
Fax: +212 23 37 01 94
Scpc Sapel
Industrial park, batch n°15. 20800 Mohammedia. Morocco
Telephone: +212 23 30 19 17
Fax: +212 23 31 42 32
Agripharma s.a.r.l.
2, gone of the Villas. 20250 Casablanca. Morocco
Telephone: +212 22 35 59 50
Fax: +212 22 34 06 83
National union of the Moroccan Agricultural cooperatives (U.n.c.a.m)
48, street of Algiers. 20000 Casablanca. Morocco
Telephone: +212 22 20 02 48
Fax: +212 22 26 24 04
Co. Morrocan woman of the Fertilizers (Fertima)
3, street Abdelkader ElMazini-ex Crow, data base Mly Youssef 1°ét. 20000 Casablanca. Morocco
Telephone: +212 22 48 43 47
Fax: +212 22 48 43 54

OVERALL ESTIMATE OF THE ORGANIC MATTER LOSSES OF THE SOILS IN MOROCCO

I Estimate of the losses in organic matter in irrigated zones

The estimate of the losses in organic matter of the irrigated soils in Morocco is treated through the example of the irrigated perimeter of Doukkala which is subjected to the same agricultural practices and the same rate of exploitation.

The annual rates loss (humus) in stable organic matter by mineralisation in Doukkala, vary from 1,9% to 3,3%. These values make it possible to quantify the fresh organic matter which would have been brought or restored to the soil in order to avoid the observed losses. Indeed, on the basis of content of 3.250 tons of soil per hectare, with an average thickness of soil coat of 25 cm (generally the thickness of the coat of soil lies between 25 and 30 cm), with a surface area of 10.000 m^2 / hectare and an apparent average density of the soil of 1,3 kg/dm^3 (generally this density is taken between 1,2 and 1,4 kg/dm^3); the content in organic matter of the soils in Doukkala is approximately 1,2 %, meaning a quantity of organic matter of 39 tons/hectare. The annual organic matter losses in Doukkala are estimated, on average, at 2,6%, that is **a loss of approximately a ton of stable organic matter per hectare per year**, particularly in stable humus. These losses can be higher for vegetable cultivations.

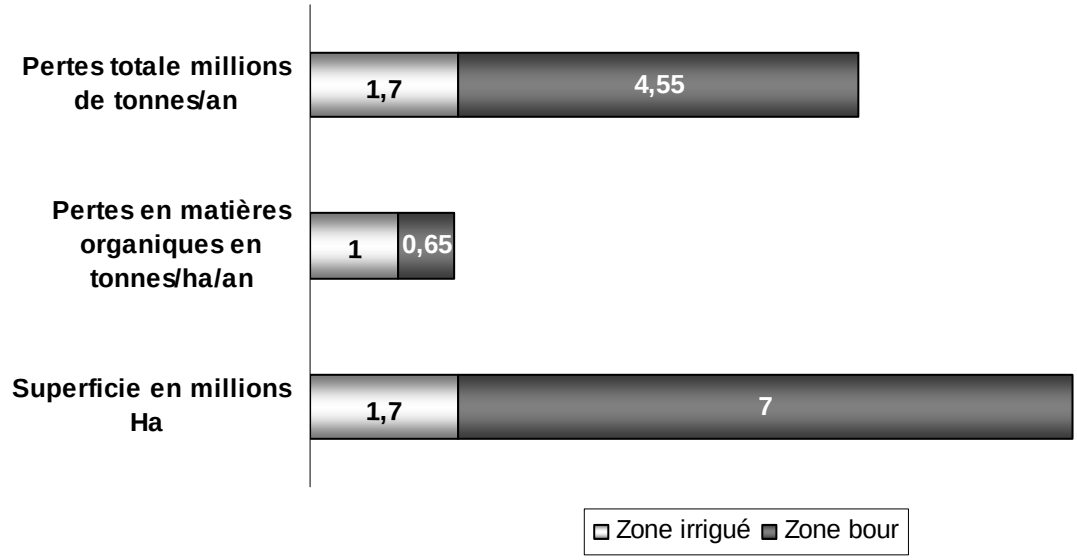
II Estimate of losses in organic matter in non-irrigated zones

In addition, the non-irrigated zones use mainly manure, at the same time, as manure for agricultural production and amendment for the soil. According to the practices observed and qualified as ¨good practices¨ on a national scale, the amounts applied are approximately 20 tones/ha, one year out of three (that is to say 6,7 tones/ha/an) without distinction between the cultures (cereals, fodder crops, arboriculture…). Knowing that the contents in dry organic matter in the manures of bovine or of sheep are generally taken between 12% and 30%, it can be deduced that the organic matter annual throughput in the non-irrigated zones is estimated on average at 1,3 tons/ha. In addition, only 50% of this organic matter is presented in the form of humus, the contribution thus in organic matter which compensates for **the annual losses of the non-irrigated soils in humus is 650 kg/hectare per year.**

III Annual Needs of soils and cultivations in stable organic matter in Morocco

On the basis of an annual loss of 650kg in organic matter/hectare in the non-irrigated soils, the requirements in stable organic matter compatible with a durable agriculture in these zones, which represent more than 7 million hectares in Morocco, are about 4,55 million tons per year.
The potential surface areas in irrigated soils in Morocco rise to 1.664.000ha out of which 1.364.000 ha of perennial irrigation and 300.000 ha of seasonal irrigation and improvement of flooding waters. If it is considered that the requirements in organic soil conditioner for the irrigated zones of Morocco are similar to those of the irrigated perimeter of Doukkala, the quantity of organic matter necessary to compensate for the annual losses which are approximately a ton of this matter, will rise to 1,7 Million tons per year.
Thus the total of **the annual needs for the soils in stable organic matter in Morocco is approximately 6,25 million tons** (fig. 3). Addressing these needs constitutes a guarantee of the durability of the agricultural systems in Morocco with a profitable agricultural production.
The use of the manure and the mobilization of new sources of organic manures are a condition indispensable of the durability of the national agricultural system (maintenance of contents of the soils of organic matter compatible with a sufficient and durable agricultural productivity). The composting of sludge and other biodegradable organic waste is a potential source of amendment for the soils in Morocco. It has the double advantage of contributing to the durability of our systems of agricultural production and of contributing to public health, the water resources and the environmental protection in the country.

Figure 3 : Overall estimate of the organic matter losses of the soils in Morocco



Part 2: SOURCES OF ORGANIC MATTER FOR AGRICULTURE IN MOROCCO AND THE MARKET OF COMPOST

SOURCES OF ORGANIC MATTER IN MOROCCO

The principal source of organic matter for agriculture in Morocco is manure, the national market of which is very disorganized. However, there exists in Morocco a limited market of peat, which is much less used than manure and is especially useful as a support in the startup of certain gardening crops or in arboriculture. The market of green manures is non-existent and this type of amendment is met only in a very limited number of farms. Compost is practically absent from the national market and its use is limited to certain seedbeds (nurseries). However, this last use has a potential of a very promising development in Morocco.

I. The market of the manure in Morocco

1 Production of manure in Morocco

a. Estimation of the production of the manure in Morocco

The potential production in manure on a national scale is estimated while referring to the literature for the annual production by species and to the statistics published by the Ministry of Agriculture on the number of bovines, sheep, goat and horses.
The references used for the evaluation of the potential quantity of manure are shown in detail in tables 12 and 13 below:

Table 12: Production of the animal manure (CORPON, 1988)

Species	Unit	Production of manure
Bovines	T/an/UGB	15
Sheep	T/an/Brebis	1,0
Goat	T/an/animal	1,3
Horses	T/an/animal	13

Table 13: Equivalences in UGB (Unité Gros Bétail) and BRE (Brebis) (CORPON, 1988)

Species		Equivalent UGC or BRE
Bovines	**Milk cow**	1,0
	Nurse cow	0,7
	Bull and young male	0,7
	Heifer	0,7
	Calves	0,3
Sheep	**Sheep mother**	1,0
	Ram	1,0
	Lamb	0,3
	Lamb	0,5

With respect to the number of layer chicken and table fowls, the numbers were addressed by considering the annual production of white meat and that of eggs brought to the average weight per capita of the sale of table fowl and of the number of eggs per hen per annum for layer

chicken. The average weight of the sale retained for table fowl is 1,75 kg per capita and the average number of eggs considered for layer chicken is 250 units per annum per capita.

b. Indirect estimate of the production of manure from bovines, sheep, goat, horses and poultry

The potential quantity of manure from principal species of the national livestock is estimated at 70,24 million tons (table 14).

It is to be announced that the quantity of manure produced per Unit Gross Cattle (UGC) was estimated for 24 hours and that for the majority of the systems of livestock production, the animals spend approximately 12 hours outside the buildings of breeding. Consequently, the quantity of manure could be estimated at 50% of the potential production; that is to say 35,12 million tons. Manure coming from poultry activity is estimated at nearly 884 thousand tons per annum.

Table 14: Indirect Estimate of the manure production from bovines, sheep, goat, horses and poultry.

Livestock	Number (2003) (1,2)	UGC or Ewe (4)	Manure (T by UGC or animal per annum) (4)	Total quantity in T/an	Kg/head/day
Bovines	**2 688 600**			**29 210 145**	**30**
Milk cow	1 212 378	1,0	15	18 185 677	
Nursing cow	250 271	0,7	15	2 627 846	
Heifer	217 449	0,7	15	2 283 210	
Bull or young male	262 526	0,7	15	2 756 519	
Beef	745 976	0,3	15	3 356 893	
Sheep	**16 743 000**			**12 639 987**	**2,1**
Ewe mother	9 105 848	1,0	1	9 105 848	
Ram	713 051	1,0	1	713 051	
Lamb	3 204 811	0,3	1	961 443	
Ewe-lamb	3 719 290	0,5	1	1 859 645	
Goat	**5 208 300**		1	**6 770 790**	**3,6**
Goat mother	2 950 856	1,0			
Goat	296 623	1,0			
Lamb	880 453	0,3			
Ewe-lamb	1 080 368	0,5			
Equidés	**1 663 400**		13	**21 624 200**	**35,6**
Chevaux	154 600				
Mule	525 400				
Donkey	983 400				
Poultry	**174 571 429**		13	**883 571**	**35,6**
Table fowl in 2004	164 571 429		4,5 *	740 571	
Layer chicken in 2004	10 000 000		14,3 *	143 000	
TOTAL				**71 128 694**	

* Manure (kg per capita per annum)

c. Estimate of the production of manure

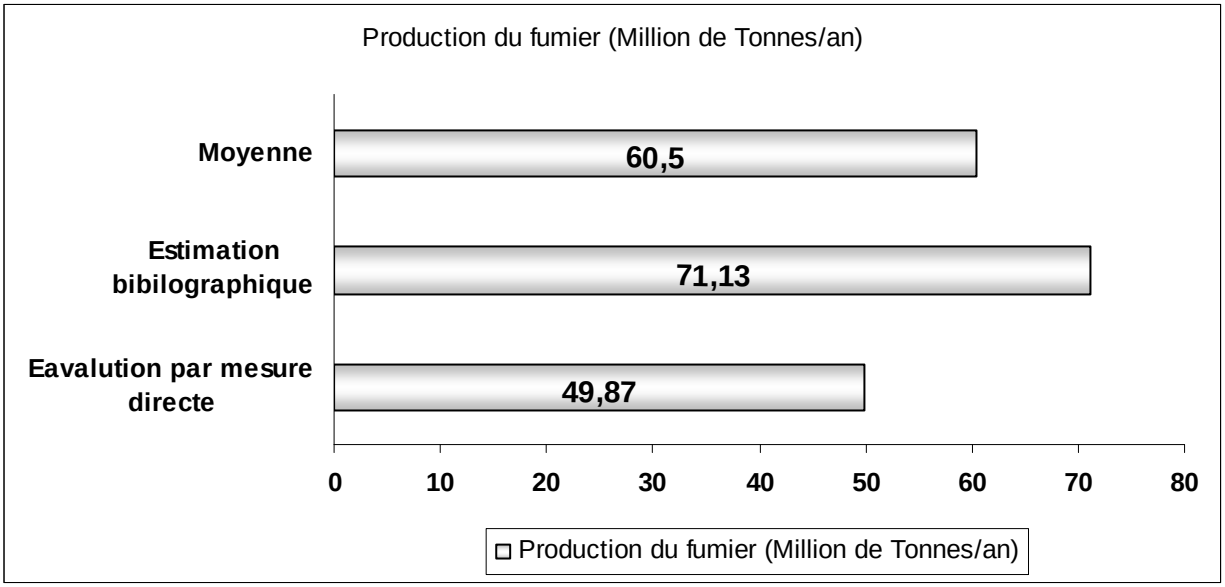
The potential quantity of manure of the principal species of the national livestock estimated, from direct measurements in the farm (table 15) is 45,5 million tons; that is to say, a production of almost 23 million tons. Manure coming from the poultry activity is estimated, from measurements, at nearly 373 thousand tons per annum.

Table 15: Production of manure from bovines, sheep, goat, horses and poultry according to direct measurements taken in the irrigated and non-irrigated zones of Doukkala.

Livestock	Number (2003)	Manure (T/head/yr)	Total quantity in T/yr	Kg/head/day
Bovines	2 688 600	9,0	24 197 400	25,0
Sheep	16 743 000	0,6	10 045 800	1,6
Goat	5 208 300	0,6	3 124 980	1,6
Horses	1 663 400	7,0	12 142 820	20,0
Table fowl (5) in 2004	164 571 429	1,4	230 400	
Layer (5) in 2004	10 000 000	14,3	143 000	
TOTAL			**49 884 4 00**	

The total annual production of manure in Morocco, evaluated by direct measurements or estimated from literature data, is presented in figure 4 below :

Figure 4: Production of manure in Morocco



2 Market of manure in Morocco

The production of manure is relatively concentrated in the northern part and in the irrigated perimeters of the Kingdom (Table 16). The marketing of manure is not organized, manure, is generally, either sold publicly to the gardening crop producers or spread in the fields without any treatment. It is characterized by its local and seasonal unavailability, implying often random and speculative prices. Sales are generally made within a non-controlled circuit. Thus, statistics on sales and selling price are very variable and unofficial. Manure is often exported from the zones of production to the zones of truck farming where it shows a profit by the often high prices of gardening products. For the cultivation of cereals, the manure used is that produced at the level of the farms or inside the same zone in order to avoid transport charges since the low harvests obtained at end of the season make it difficult to support. The needs in manure are very significant, therefore the quantities to be transported are high and the cost excessive.
Selling prices are very variable and dependent on precipitations. Thus, the prices of manure vary according to their quality from 100 to 200 Dirham per ton.

Table 16: Geographical distribution of the production of animal manure in Morocco

Area	Production of manure (Tons/year)
Chaouia-Ouardigha	4 073 600
Doukkala-Abda	6 319 500
Fès-Boulmane	1 604 700
Gharb-Chrarda-Beni Hssen	4 338 000
Large Casablanca	497 000
Guelmim Es Semara	311 200
Marrakech-Tensift-Al Haouz	6 823 400
Meknès-Tafilalet	3 051 100
Wadi ED-Dahab –Lagouira	2 920 100
Area of the Eastern one	2 520 700
Souss Massed Draa	4 984 300
Tadla-Azilal	3 017 100
Tangier-Tétouan	4 427 100
Taza-Al Hoceima-Taounate	4 623 100
Total	49 510 900

Admittedly manure provides a fermentable organic matter not broken up, however it causes the immobilization of nitrogen after the contribution and is likely to create a depressive effect on the young seedings and damage to sowings and cultivations. Manure conveys casual seeds of plants and of phyto-pathogenous germs. The transfer of manure from one region of Morocco to the other becomes not only one factor of inter-regional transfer of the fertility of the soils but it also means the transport of the insects, seeds of bad grasses and nematodes in the gardening crop areas. Consequently, the intensive use of the pesticides is imposed as well as the risk of rate rise of the residues on products. Often, too wet manure does not allow a uniform spreading. Manure is often expensive to purchase, to transport and it requires much hand work and danger to polute water resources.

3 Cost of stable organic matter originating in manure

The contents in dry organic matter, in the manures of bovines and sheep, lie between 12% – 17% and 28% – 32%, respectively. The contents of stable humus are approximately 7,5% and 12,5% respectively in the manures of bovines and sheep. Table 17 presents the quantities and the price of organic matter and of the stable humus obtained from manure.

Table 17: Cost of stable organic matter originating in manure

Material	Manure of sheep	Manure of bovines
Dry organic matter (thousands)	280 to 320	120 to 170
Humus (thousands)	100 to 150	50 to 100
Production of manure (million Tons/year)	12,64	29,21
Production of dry organic matter * (Million Tons/yr)	3,78	4,23
Production of stable humus * (Million Tons/yr)	**0,47**	**0,32**
Average selling price of manure in DH/ton	200	150
Cost of the humus from manure in DH/Kg	**1,60**	**2,00**

* average value

NB: This evaluation of the price based on the richness of manure in stable humus partly neglects the role of manure as a fertilizer of the soil by its contribution in directly assimilable nutritive elements.

4 Contribution in manure and requirements in organic matter for the soils in Morocco

In the preceding chapter we have evaluated **the annual needs of the soils in stable organic matter in Morocco to approximately 6,25 million tons.** In order to compensate for the losses of the soils in stable organic matter, it would be necessary to bring a quantity of manure containing the equivalent of this quantity of humus.

The national production in manure of bovines is 29,21 million tons/yr with a humus rate of 75 kg/ton with a total production of humus of **2,19 million tons/yr**. As for the national production in manure from sheep, it is 12,64 million tons/yr with a humus rate of 125 kg/ton with a production of humus of **1,58 million tons/year**.

The production of the manure from horses and goats is 6,77 and 21,62 million tons/yr. Based on an assumption of 100 kg/ton of stable humus, the quantity of stable organic matter of this type of manure rises to **2,84 million tons/yr**.

Manure from poultry was not taken into account given the low annual production (0,88 million tons/yr) and its low content in stable organic matter.

The annual total production in stable organic matter from manure is 6,61 million tons/yr. The mobilization of this quantity constitutes a guarantee of the durability of the agricultural systems in Morocco, thus guaranteeing a minimum agricultural production. This evaluation could satisfy the needs of the soils in stable organic matter in Morocco. However it would be necessary to support all the disadvantages caused by this type of organic soil conditioner as noted previously.

In addition, the productions of the manures used in this evaluation of sources of stable humus in Morocco, are potential productions, based on indices (CORPON, 1988). On the basis of these indices the total production of manure in Morocco would be 71,13 million ton/yr. However, this production is only 49,88 Tons/yr and corresponds to a mobilizable production.
Mobilizable production represents 70,12 % of the potential production of manure in Morocco. The quantity of the corresponding stable organic matter would hardly exceed 4,63 million tons/year. **The loss of earnings in this second case is 1,57 million tons of stable organic matter per year. Thus the mobilization of other sources of stable organic matter is to be researched to avoid the degradation of arable soils in Morocco.**

II The market of Compost in Morocco

1. General information on compost

Compost has two major roles: a fertilizing role which lies in the progressive supply of the nutritive elements to the cultivated plants and the reinforcement of the effectiveness of mineral manures brought, and a role of improvement of the physical properties of the soils (retention of water, structure e.t.c). It is clear that the availability of certain nutritive elements decreases during composting but this reduction is compensated by the other advantages offered by compost.

The use of compost as a product of amendment has several advantages compared to the incorporation of fresh manure or of other not decomposed organic residues. Indeed, manure conveys, from one region to the other, the insects, the seeds of casual plants and the phytopathogenic germs. These problems are entirely eradicated by the process of composting during the thermophilic phase. Recent research shows that the incorporation of compost to the soil allows, through the development of competitive saprophytes, to inhibit certain phytopathogenic germs. In addition to these advantages, via composting the volume of waste is reduced by approximately 45% to 50 %, which makes its application and its transportation more convenient and less expensive.

The humic inheritance of the soils is non-extensible and remains rather prone to colossal losses because of bad management of the crop waste products, of the use in cultivation of distant soils, or to fight the phenomenon of erosion and also other non-rational practices.

This phenomenon is rather well expressed in the irrigated perimeters where the addition of the crop waste products in the soil is almost null. Let us add to that the fact that these losses are amplified by the process of a rather intense mineralization, due to the hydrous and thermal conditions which favor the mineralization of micro-flora in these regions.

In addition to the use of compost as an organic conditioner of the soil, it can be also used for the manufacture of the substrates of cultivations and the pots of seedbeds of decorative and forest plants. The biological sector of agriculture is also an excellent field of assessment of the compost.

All matter of vegetable and animal origin, like all biodegradable waste, is compostable. However, a certain number of parameters of the raw material and/or mixture of two or several ingredients are significant to consider for the start and the good running of the process of composting. The richness of the produced compost depends on the nature and the proportions of the various ingredients. It should be stressed that in Morocco, there is a variety of biodegradable organic waste that can be composted (sludge from waste water, manure, green agricultural waste generated by the cultures in greenhouses, and other products of great value for composting).
The compost is an organic manure and at the same time an amendment for poor soils. Table 18 presents the principal characteristics and comparative advantages of compost with respect to manure.

Table 18: Comparative advantages of a good mature compost and of manure

Mature Compost	Manure
Provides an organic matter more humified, more stable and of constant quality.	Provides a fermentable organic matter not decomposed.
Support a progressive release of nitrogen and nutritive elements immediately after its contribution.	Cause the immobilization of nitrogen after its contribution and it is likely to involve a depressive effect on the young seedlings and damage of sowings and of cultures.
The nematodes, pathogenic agents and seeds of bad grasses are destroyed thanks to the rise in the temperature between 65°c and 70°c during composting	Contains a significant polluting load and is likely to infest the cultures via the nematodes and other parasites as well as bad grasses. The intensive use of pesticides is imposed and there is risk of rise in the rate of residues of products
Allows an easy and uniform spreading, even in low dose, thanks to its crumb and friable structure.	Often too wet and does not allow a uniform spreading.
The amounts of application are low, thus the transported volumes are reduced.	Significant needs, therefore high quantity to be transported, hence high cost.
Available all the year.	Local and seasonal unavailability.
Less expensive by respecting the advised doses.	Expensive during purchase, transport and requires much labour.

2 Traditional Technique of compost production (composting in pile)

Three essential parameters must be controlled to guarantee a good start of composting: the ratio C/N, the moisture of the mixture and the size of the particles.

The **ratio C/N** must lie between 25 and 35 (preferably around 25). If the ratio C/N is lower than 20, we have a nitrogen loss and a production of ammonia and thus the emanation of bad smells. If C/N is higher than 40, the process of bio-degradation becomes slow. For that, a mixture of carbonated and nitrogenous matter is recommended.

Water content (**moisture**) is a significant factor in the activity of the micro-organisms. In practice, it is advisable to avoid high moisture because the excess of water displaces air from the lagoon space of the composting pile, and initiates anaerobic conditions since air is not diffused

within the pile. The anaerobic conditions usually to occur at a water content level higher than 65 to 70%. The optimal water content for the process of composting lies between 50 and 60%.
The size of matter for composting must lie between 1,3 and 5 cm to facilitate bio-degradation. For that, grinding must be carried out when the materials exceed this size significantly. It must be noted that granules should not be fine either, to avoid compressing of the pile and consequently a reduction of the air circulation.

3 Production and use of compost in Morocco

The production of compost in Morocco is very limited, even non-existent. Indeed, there were cases on a pilot scale in the structures of public and private. Some small scale composting units were constructed the past few years, in particular in the towns of El Jadida, Marrakech and Rabat but the quantity of compost produced is negligible and essentially there is no marketing of these composts. The composted materials used are mainly domestic waste, restaurant left-overs and coffee grounds while the purchasers are often, nursery growers and certain horticultural farms.

Moreover, certain attempts at composting by industry were noted. These actions are timid but they will have a significant future with the development of the biological garden crops. A company based in El Jadida, markets produced compost, on the basis of coffee grounds. The product is marketed on a national scale, its selling price is 60 DH per bag of 50 kg with a moisture content of 40% or dry matter at 2DH/kg.

III The market of peat in MOROCCO

Peat is a vegetable tender rock made up of:

- 10-20 % of vegetable organic matter
- 80-90 % of water, at the end of the peat bog.

Dry, a block of peat burns as coal because it contains up to 50 % of carbon. The fair peat (color of tobacco) comes from the surface layers, the remainder of the vegetables are well recognized. The brown peat is thicker, better decomposed. It is found in flat peat bogs but also in the deep layers of peat bogs on the mountain. It is a sought-after fuel.
However, contrary to manure and compost, peat is not manure. It is used by the horticulturists for its properties of water retention and support of culture. Cups can also be made out of it for flowers and vegetables. It contains little rock salt. Moreover, it is acidic, something plants do not appreciate.
Peat is marketed in Morocco at the price of 65 DH/80 liters at a humidity of 50% or 2,30 DH/kg of dry matter.

COMPOST PRODUCED BY THE MOROCOMP TECHNOLOGY

The compost produced from the in-vessel composting unit (MOROCOMP) originates from sewage sludge and other biodegradable organic waste (BOW). Waste water treatment plants produce large quantities of sludge and in the case of Morocco the volume of waste water rejected was estimated at 550 mm ^{3} / year in 2005 and it will reach 900 mm ^{3} / year by 2020 (the Higher Council of Water and the Climate, 2001).
In view of the environmental problems and of public health; of the increase in demand for water for human, industrial and agricultural consumption, and in view of the repeated drought which prevails in Morocco, waste water is currently regarded as an appreciable hydrous resource. This is why the governmental authority has set up a national programme of treating waste water. This programme aims amongst others, to the reinforcement of the infrastructures of waste water treatment and has as an objective to tackle the pollution of water resources at 60% by 2010 (Action plan 2005-2007, Ministry for the Environment and Water, Regional planning). The volume of treated waste water at the level of the 72 sewage plant stations of Morocco is approximately 8% and generates 13.770 tons of sludge. In addition, the actual production of sludge from the sewage plant network of urban zones is estimated roughly at 9900 tons. Thus the potential of sludge produced in Morocco rose to 23.310 tons in 2005. Projections for 2010 envisage a production of sludge of approximately 123.300 tons.
The most promising methods of sludge management is through anaerobic digestion and the parallel production of biogas as heat source and electricity or through composting and land application.

In addition, texture, chemical composition of sludge and the use of the end product, condition the systems of composting. The latter sometimes require additions of materials of mineral nature (clays allowing mixing of heavy metals) and/or of organic nature to adapt the C/N/P ratio or to improve the texture and the quality of the final compost. Thus, biodegradable organic waste (BOW) is of everyday usage in the composting systems of sludge coming from sewage water plants, making it possible to adjust and improve the quality of composts. Thus composting can treat BOW and sewage sludge plants at the same time.
Morocco, a country whose economy is based mainly on agriculture, arranged several irrigated perimeters to improve the agricultural production and the development of these zones. However, the intensive soil cultivation systems at the level of these perimeters cause their degradation in organic matter, in particular in the Doukkala region. Thus compost constitutes a local source of stable organic soil conditioner which is not very expensive.
Thus project MOROCOMP would contribute in the research for innovative alternatives through the use of sludge and other biodegradable organic waste which, until now, are not used in agriculture.

I Evaluation of the production of sludge and other biodegradable organic waste in Morocco

If the production of sludge is easily quantifiable in comparison with the data available, the diversity of BOW sources and the scarcity of official statistics on BOW imposed the adoption of a particular strategy of work. Thus, the teams involved in the MOROCOMP project, chose a

methodological step which allowed, for the first time in Morocco, to establish a quantification of sludge and of the various BOW sources by type and by region in Morocco.
The methodological approach consisted of i) the realization of an inventory of sources of BOW and of sludge, ii) the quantification of each source (investigation, visits, direct evaluation, research on the Web, consultation of official files) and iii) the compilation and the summary of the results obtained by activity sector and region of Morocco.
Thus, the five types of sludge sources and the BOW which were listed according to their importance in quantity and quality are as follows:

- Sludge of waste water treatment plants
- Sludge of sewage networks
- Waste of the food processing industry
- Waste and residues of the agricultural productions
- Residues of wood processing and of waste from slaughter-houses

The production of each type of waste (sludge and BOW) was in part the evaluation object in order to highlight its potential on a regional and national scale in view of a rational exploitation by composting. This evaluation required a method of quantification adapted to each type of biodegradable organic waste.

1 Method of quantification of sludge and of BOW

The annual production of sludge at the level of water treatment plants used in Morocco was evaluated on the following basis: waste water treatment generates the equivalent of 30 to 40 grams of dry matter (DM)/inhabitant/day in the form of sludge.
The estimate of the quantity of sludge from the waste water treatment network of the cities was based on the data of the DGCL which stipulates that waste water circulating in the sewage network contains on average 10 % of sludge of which 50 % really undergoes assessment.
As for the biodegradable organic waste generated in Morocco by the food processing industry, the estimate of their production was carried out on the basis of statistics available at the level of the ministry for agriculture and the ministry for industry and also based on available bibliographic studies.
The biodegradable agricultural residues generated in Morocco were subdivided into three types: i) green residues, dry residues and manure. The production of residues was evaluated either from the bibliographical data, or measured at the level of certain cultivations and then extrapolated on a national scale.
The estimate of the quantities of biodegradable organic waste generated by the wood processing industry was evaluated from official statistics and bibliographical data.
The waste produced by the slaughter-houses was estimated based on of i) bovines: 0,38 tons of solid waste and 36 liters liquid effluents per ton of produced carcass; ii) sheep and goats: 0,48 tons of waste and 83 liters of liquid effluents per ton of produced carcass.
The estimate of the production potential of sludge and of BOW was often based on the produced average quantity per inhabitant of the population concerned.

2 Quantification of sludge and of BOW

The annual potential and activated production of each type of waste is presented in tables 19 and 20.

The potential production of sludge at the level of water treatment plants is estimated at 435.600 tons/year for a rate of connection to the STEP of 100%. With a rate of connection of approximately 3,2%, the activated production of sludge is estimated at 13.770 tons/yr.

The quantity of sludge which can be extracted from all the waste water sewage networks in Morocco for the year 2006 was approximately 14.700 tons **(**according to the estimates of the Directorate-General of the Local Communities and the Ministry for the Moroccan Environment and Water, Regional planning).

The potential production of biodegradable organic waste by the food processing industry in Morocco is estimated, according to the available statistics, to approximately 532.000 tons/yr. The activated production is estimated at 465.900 tons per annum of which the sugar industry accounts for 78%.

In addition, agriculture is a strategic sector for the national economy in terms of income and employment. This sector constitutes the principal source of biodegradable organic waste in Morocco. The various residues and waste were grouped in three classes (green residues, dry residues and manure).

The potential production of residues is evaluated, to the maximum, to approximately 88.8 million tons per annum of which manure constitutes 80 %. There is a limit to the estimate of the activated production in dry residues of the cereal field crops (straw) and of the animal manure (bovines, sheep, goats and horses), being given strong consideration to the green residues (animal feeds) and the manure of poultry farming (truck farming). Thus the activated production of agricultural residues is approximately 64,3 Million tons per annum of which manure constitutes 77%.

The Moroccan forest is made up of 500.000 ha of reforestation, of 3,3 million ha of layers alfatières and 5,8 million ha of natural forests with 82% leafy and 18% of conifers. The national average of the cover rate of these forests is 13 %. The potential production of solid **residues** generated by the timber industry in Morocco was established at 468.803 tons per annum, whereas the activated production of this line is estimated at 168.803 tons per annum.

In Morocco, the sector of the slaughter houses for the preparation of red meats includes: 185 municipal and Community slaughter-houses and 740 slaughters in open-air marketplace in Morocco (souks). In 2004, 314.680 tons of meat was produced. The total quantity of biodegradable organic waste produced by the slaughter-houses in Morocco was estimated at approximately 130.000 tons/yr.

3 Quantification of BOW by region

The geographical distribution of the annual production of each type of waste (sludge and BOW) activated at the level of the 16 administrative regions, that account for Morocco, is presented in table 21.

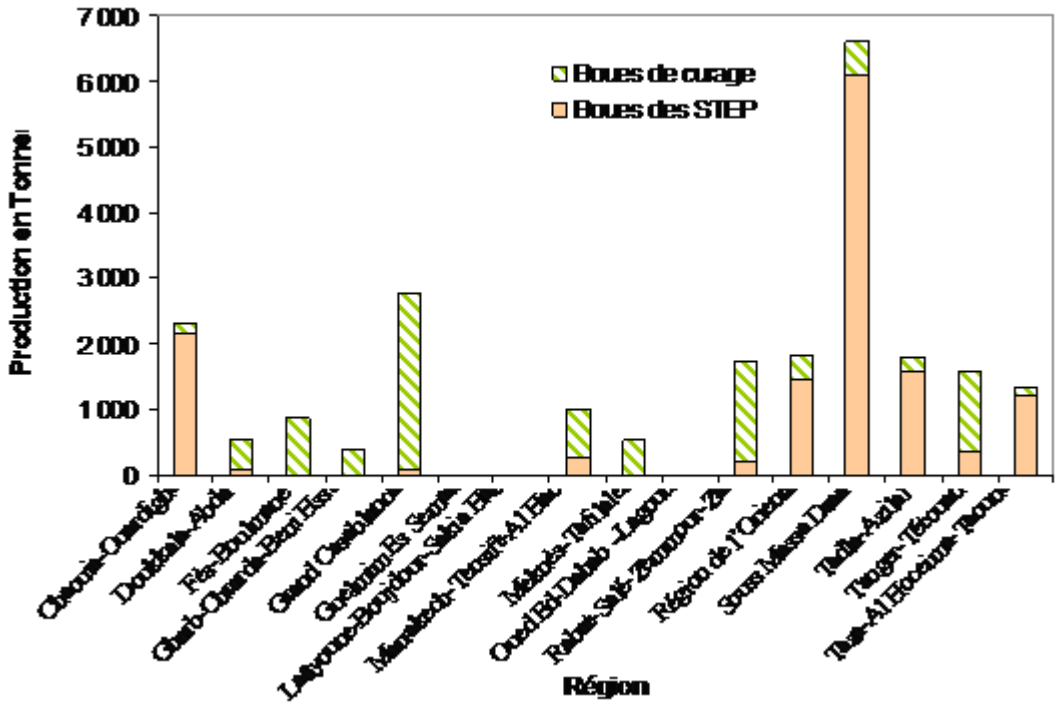
The activated production of sludge at the level of the STEP and of the urban water sewage networks in the various administrative regions of Morocco is presented in figure 5.

It is noted that in the majority of the regions, the activated production of sludge exceeds 1000 ton/yr except in the regions of Doukkala-Abda, Fès-Boulmane, Gharb-Chrarda-Bni Hsin and Mèknès-Tafilalt. The production of sludge is almost negligible for the three southern regions of Morocco namely: Wadi ED-Dahab –Lagouira, Laâyoune-Boujdour-Sakia Hamra and the Guelmim-Es Semara region.

In figure 6, there is a summary of the geographical distribution of the production of solid waste produced by food processing industries, timber industries and slaughter-houses**.**

It is noticed that with the exception of the three areas of the Moroccan south (Wadi ED-Dahab – Lagouira, Laâyoune-Boujdour-Sakia Hamra and Guelmim-Es Semara) where the production of BOW is negligible, other areas produce rather significant quantities of BOW.

Figure 5: Geographical distribution of the activated production of sludge in Morocco



The geographical distribution of the production of dry residues and manure of the livestock at the level of various regions of Morocco, is presented in figure 6. This reveals that a significant quantity of activated agricultural BOW is produced in all regions of Morocco except the three areas of the Moroccan south.

Figure 6: Geographical distribution of the activated production of biodegradable organic waste in Morocco

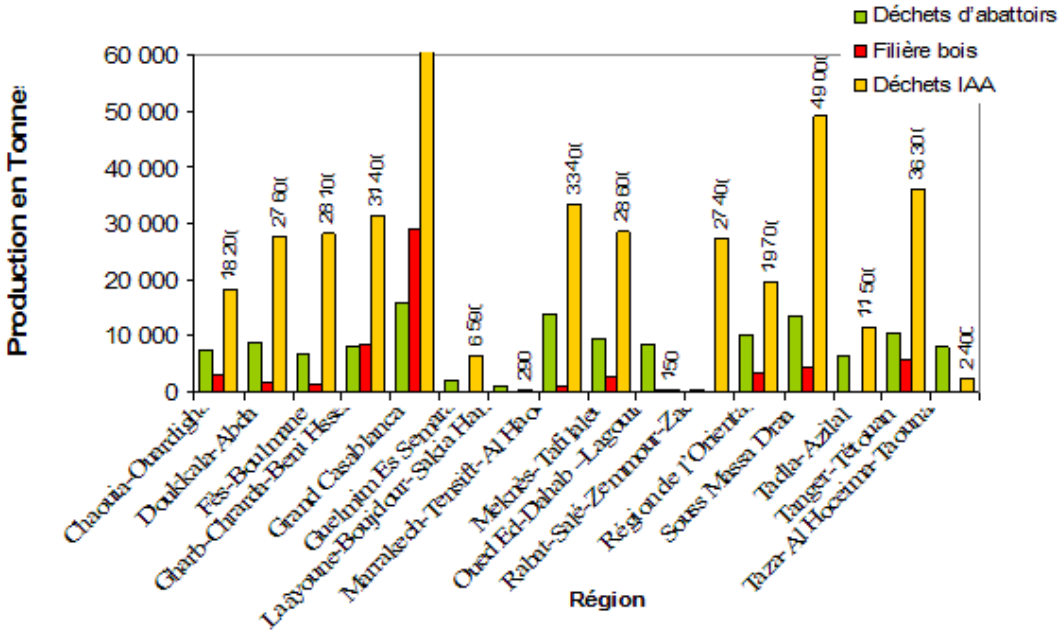


Table 19: Production of sludge in Morocco (2005).

Nature of waste	Origin	Activated quantity (ton/yr)	Activated quantity %	Potential production (ton/yr)
Sludge (in dry Matter)	Station of waste water treatment	13 770	58,2	438 000
	Urban sewage networks	9 901	41,8	14 700
Total		**23 671**	**100**	**452 700**

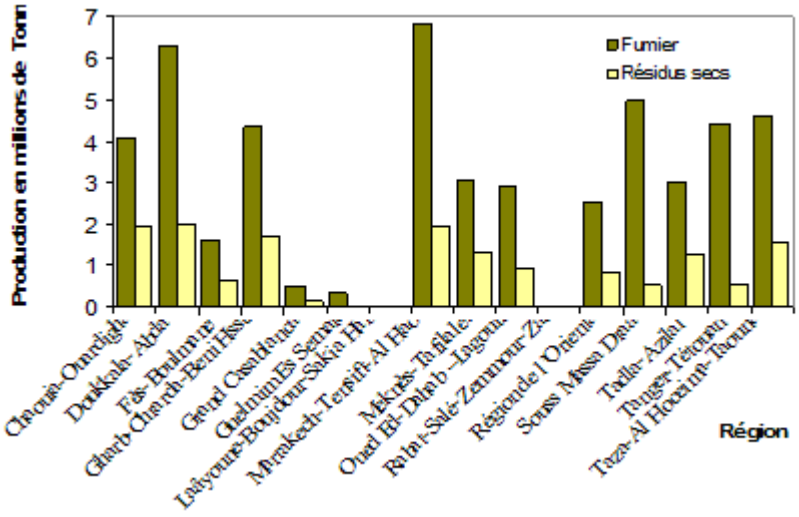
Table 20: Production of biodegradable organic waste in Morocco.

Nature of waste	Origin	Activated quantity (ton/yr)	Activated quantity In %	Total potential production (ton/yr)
Waste food industry	Sugar industry	365 000	0,54	
	Fish canning facilities	12 400	0,02	
	Oil mills	77 500	0,11	532 000
	Dairy industry	8 000	0,01	
	Industry of tobacco	3 000		
Agricultural residues	Cereal cultures	14 769 903	21,70	
	Cultures (vegetables, beets, sugar canes, sunflowers)	618 211	0,91	15 388 114
	Green residues (potato, tomatos, etc.)	1 731 000	2,55	1 731 000 to 2 282 000
	Manure (bovine, sheep, goat, horses)	49 511 000	73,00	49 511 000 to 70 250 000
	Manure (poultry farming, chicken)	373 400	0,55	373 400 to 883 600
Wood residues	Sawmills	108 603	0,16	
	Timber	19 000	0,03	
	Paper, paperboard and printing works	41 200	0,06	468 803
Waste of slaughter-houses	Red meat slaughter-houses	130 000	0,19	130 000
		Total: 67 768 217	**100**	**68 584 617 to 90 384 817**

Table 21: Geographical distribution of the activated production of sludge and biodegradable organic waste in Morocco

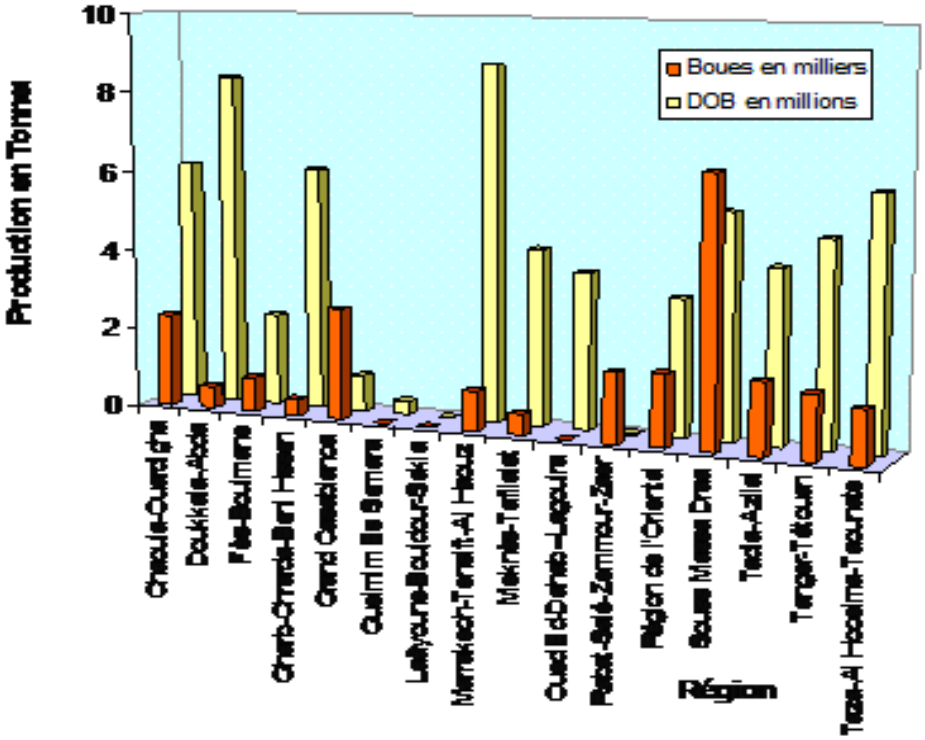
Area	Production (Tons/yr)							
	Sludge of STEP	**Sewage Sludge**	**Waste of slaughter-houses**	**Timber line**	**Waste IAA**	**Manure**	**Dry agricultural residues**	**Total Tons/yr**
Chaouia-Ouardigha	2 158	155	7 300	2 800	159 434	4 073 600	1978 100	6 223 547
Doukkala-Abda	67	479	8 700	1 700	24 178	6 319 500	1993 600	8 348 224
Fès-Boulmane	0	866	6 900	1 300	24 616	1 604 700	649 100	2 287 482
Gharb-Chrarda-Beni Hssen	0	391	8 000	8 200	27 507	4 338 000	1699 900	6 081 998
Large Casablanca	73	2 707	16 000	29 200	185 018	497 000	139 100	869 098
Guelmim Es Semara	0	0	2 000	0	5 773	311 200	15 500	334 473
Laâyoune-Boujdour-Sakia Hamra	0	0	1 000	0	254	0	0	1 254
Marrakech-Tensift-Al Haouz	248	756	13 700	1 000	29 259	6 823 400	1978 100	8 846 463
Meknès-Tafilalet	0	536	9 400	2 600	25 055	3 051 100	1298 200	4 386 891
Wadi ED-Dahab –Lagouira	0	0	8 400	200	131	2 920 100	958 100	3 886 931
Reduction-salted-Zemmour-Zaer	198	1 534	430	0	24 003	0	0	26 165
Region of the East	1 452	358	10 000	3 100	17 258	2 520 700	849 900	3 402 768
Souss Massed Draa	6 076	536	13 500	4 400	42 926	4 984 300	509 900	5 561 638
Tadla-Azilal	1 584	203	6 400	100	10 074	3 017 100	1267 300	4 302 761
Tangier-Tétouan	333	1 262	10 500	5 500	31 800	4 427 100	571 800	5 048 295
Taza-Al Hoceima-Taounate	1 220	118	7 900	100	2 102	4 623 100	1545 400	6 179 940
Total	13 409	9901	130 130	60 200	465 900	49 510 900	15 454 000	**65 644 440**

Figure 6: Geographical distribution of the production of manure and of agricultural residues in Morocco



It is noted, that for the regions where there is a significant production of sludge, there are significant resources of biodegradable organic matter (see figure 7). These BOW can be used for a combined assessment with sludge.

Figure 7: Geographical distribution of the activated production of sludge and biodegradable organic waste in Morocco



II Availability of sludge and other BOW in Morocco

If the actual production of activated sludge is 13.770 T/yr, forecasts envisage a production of 123.300 T/yr by 2010 (that is a 9 fold increase). It is thus very significant, for Morocco, to set up a system of management and assessment of this source of organic matter of which the inappropriate management can inevitably lead to major problems of the environment and of public health.

Apart from the specific tests performed in Ouarzazate and Ben Sergao where sludge is produced from treated waste water of exclusively domestic origin, no conclusive experimentation as regards to the assessment of waste sludge in Morocco was reported. Sludge is primarily dried and deposited near the treatment plants or in disposals or certain cases in the soil without preliminary treatment.

As for the BOW, the most significant sources, are the agricultural residues the potential production of which varies between 67 million and 88,8 million tons per annum whereas that generated by other economic activities is estimated at 1,5 million tons per annum. The principal agricultural residues are manure (73%) and the straw of cereals (21%). These two residues are easily activated if their integration into the line of composting allows them more competitive value.

III Production Potential of compost by the MOROCOMP technology

The initial composition for the production of compost according to the MOROCOMP process is as follows: 30 to 50% sludge and 50 to 70% BOW. The composition of the BOW varies according to the optimal conditions necessary to start the process of composting.

The preparation of the compost requires 8 to 12 days in an aerobic bioreactor and 2 to 3 weeks of maturation in a pile with air supply and finally a maturation of completion in a sack. Generally, 35 to 40 days are enough to obtain mature compost directly usable. The final quantity of compost produced is approximately 55% of the weight of materials used initially.

The potential of production of the compost is intrinsically related to the production of sludge and its quality. Sludge from food processing industries and domestic waste water treatment plants is very good matter to make compost complying with the requirements for quality for vegetable production and with the standards of environmental protection.

Table 22 below, presents the evolution of the production of sludge in Morocco in comparison with the evolution of the construction of STEP and the production of wastewater in Morocco. This production is estimated on the following bases:

- evolution of the production of the wastewater in Morocco (http://doc.abhatoo.net.ma/DOC/IMG/pdf/eaux_usees.pdf.) ;
- production of 100 liters of waste water per inhabitant per day in urban environment.
- production of 30 with 40g (dry matter) of sludge per inhabitant per day
- the national programme of liquid and waste water treatment used over the period 2007-2015 which envisages to reduce the rate of the pollution of 60 % by 2010 and 80 % by 2015.

Table 22: Evolution of the production of wastewater sludge

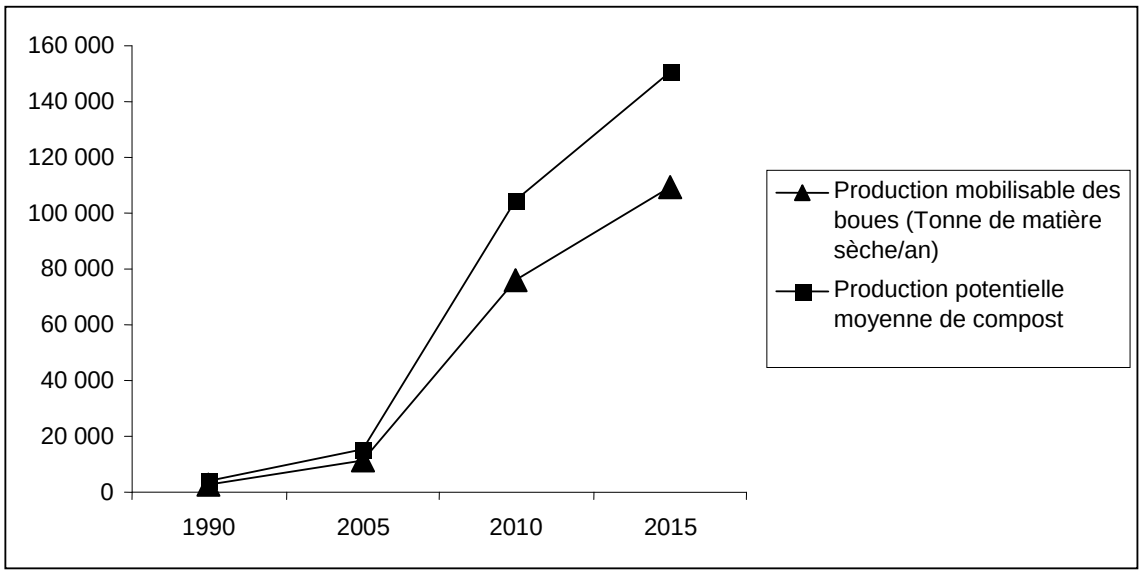
Year	1990	2005	2010	2015
Production of water used in million m^3	370	550	670	780
Potential production of sludge (Tons of dry matter /yr)	247 000	366 000	446 000	520 000
Activated production of sludge (Tons of dry matter /yr)	2500 - 3300	8500 – 13800 *	65000-87000 **	94000-125000 **

*: activated from urban waste water

**: projections according to the national programme of liquid and waste water treatment

The total capacity of production of compost according to the MOROCOMP process is estimated 83.000 –140.000 by 2010Tons of dry matter and will reach 120.000 to 200.000 Tons by 2015 (Figure 8).

Figure 8: Evolution of the potential of production of compost containing sludge from the waste water used over the period 2009 - 2015



IV Selling Price of the MOROCOMP compost

The compost produced according to the MOROCOMP technology will be marketed in sacks of 50 kg as it is the case for compost from coffee grounds marketed in Morocco. The selling price of MOROCOMP compost is estimated at 90 Dirham/50 kg of dry matter. The price takes into consideration all the costs relating to the production of compost and its marketing. In addition, the price takes into account the competitive products either imported or produced in Morocco (table 23).

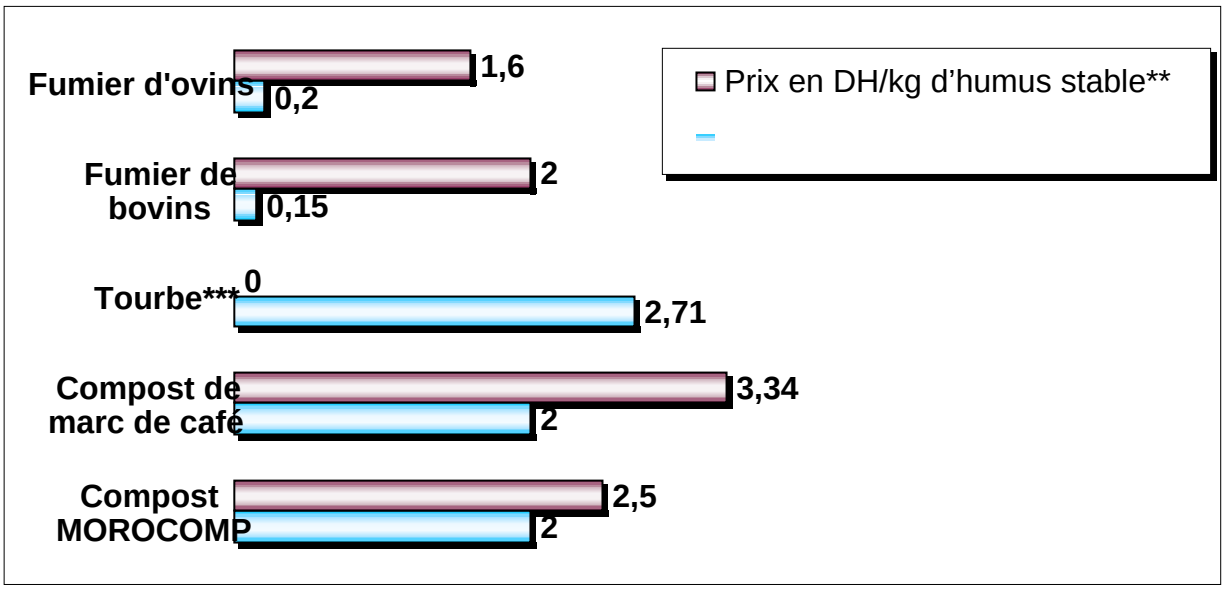
Table 23: Comparison of the cost of stable humus from compost produced by the MOROCOMP process with other marketed organic manures in Morocco.

	Conditioning in kg	Price in DH	Moisture %	Price in DH / kg of Dry matter *	Price in DH/kg stable humus **
Compost MOROCOMP	50	70	20	2,00	2,50
Compost of coffee grounds	50	60	40	2,00	3,34
Dig peat ***	80 liter (= 48kg)	65	50	2,71	-
Manure of bovine	1000	150		0,15	2,00
Manure of sheep	1000	200		0,20	1,60

*: taking into account of % moisture
**: on the basis of 50% of stable humus in the composts
***: density 0,6 kg/liter

The selling price of compost produced according to the MOROCOMP process, reported in kg of stable humus, is lower than that of other organic manures (figure 9), though that relating to manure is very competitive. Indeed, the advantages of the MOROCOMP compost over those of manure were quoted in the preceding chapter on one hand and on the other hand, it is necessary to mobilize a large volume of manure (transport charge, obstruction of the buildings, olfactory harmful effects…) that is reflected on the competitiveness of manure compared to compost.

Figure 9: Comparison of the prices of the stable humus from organic manures marketed in Morocco



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