

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND
TECNOLOGY, KUMASI

INSTITUTE OF MINING AND MINERAL ENGINEERING

DEPARTMENT OF MINERAL PROCESSING AND EXTRACTIVE
METALLURGY/MATERIAL SCIENCE AND ENGINEERING

TOPIC

*A Public Perception on Sanitation and Domestic Waste Management and Reuse in Ho
and its Environs.*

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE MASTER OF SCIENCE DEGRE IN ENVIRONMENTAL
RESOURCES MANAGEMENT.

BY

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SEPTEMBER, 2000.

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KUMASI-GHANA

ACKNOWLEDGEMENT

To God be the glory for His guidance, care, and protection.

I wish to express my sincere thanks to Est. Awuch (Mrs), my supervisor, who

in the first place has inspired me to undertake a project such as this. I am thankful to

her for her devotion, constructive criticisms, and prayers.

DEDICATION

DEDICATED TO MY WIFE,

BEAUTY ANKUTSE,

and

CHILDREN,

MAWUSE FOE- AHORNEY

SETOR FOE- AHORNEY

SEYRAM FOE-AHORNEY

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E. S. AHORNEY

SEPTEMBER, 2020

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I wish to express my sincere thanks to Esi Awuah (Mrs), my supervisor, who in the first place has inspired me to undertake a project such as this. I am thankful to her for her devotion, constructive criticism, and prayers.

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SEPTEMBER, 2000

ABSTRACT

No sanitation services are provided by the District Assemblies in the rural area. Sanitation services are however provided in the urban area. These are mainly solid waste collection, septic tank emptying, and provision of public toilet.

Out of the population interviewed, 24% are fully satisfied, while 10% are not satisfied with sanitation services. The majority of the respondents (66%) were partially satisfied.

Ho District Assembly evacuates about 66.58m^3 of refuse daily. There is a regular flow of domestic waste as 86.7% of the people with refuse bins empty their bins daily. The current solid waste that is generated could yield 613.2 tons of compost annually. Waste sorting is not a common feature in both urban and rural communities. Nonetheless, 66.6% of the respondents accept that compost pits could be constructed in their premises.

Composting of refuse may be feasible as 76.3% of both urban and rural population are willing to consume food crops produced from domestic waste compost. On the other hand, only 35% are willing to eat fish reared in domestic wastewater.

The public (75.2%) is willing to pay for good sanitation services but in practice, they are not able to sustain payment. People who do not own toilet facilities are willing to pay ₵50.00 for each visit to a public toilet.

An amount of about ₵843,541,870.00 will be required as investment capital and about ₵84,354,326.00 as annual running cost to undertake compost processing in Ho. This project could yield ₵153,300,000.00 annually.

It has been recommended that, there should be further studies on the effect of income and educational levels on waste management practices.

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LIST OF ACRONYMS.

KVIP.	Kumasi Ventilated Improved Pit Latrine.
WHO	World Health Organisation.
SSNIT	Social Security and National Insurance Trust.
E.C.	European Community.
ESAs.	External Support Agencies.
MoFA	Ministry of Food and Agriculture.
EPA	Environmental Protection Agency.
HDA.	Ho District Assembly.
U. K.	United Kingdom.
CIDA.	Centre for International Development Agency.
NPV.	Net Present Value.

INTRODUCTION.

An important aspect of the consequences of human activity is the generation of waste materials; knowingly or otherwise these waste materials are improperly disposed off. This has given rise to numerous environmental problems, which need to be addressed, else the majority of the human race will perish. This situation is more critical and threatening in urban centres than in sparsely populated areas. N'dow (1996) pointed out that by the year 2,000, half of humanity will be living in urban areas where most economic activity will take place and where most pollution will be generated and most natural resources consumed.

Several alternatives might exist to address waste problems in a community. The choice and efficacy of any method or combination thereof would depend on a lot of factors. Notable among the factors is the human element that might be involved. This calls for thorough understanding of the issues at stake and a driving desire to adopt a particular approach through education. Thus, the type and quality of education offered in waste management is very important.

Waste Management covers the planning, operation and maintenance of strategies and systems for the management of materials for which there is no further use (Bailey, 1996). The sustainability of any waste management system would, to a large extent, be governed by some economic considerations. The implementers of the waste management system would compare the cost and benefit of the various options that exist in a free economic environment. This consideration might be misleading if a thorough environmental impact assessment is not adopted.

The United Nations Environment Programme (UNEP) enjoins all nations to formulate an Environmental Action Plan (EAP) following the United Nations Conference on Environment and Development (UNCED) summit in Rio de Janeiro, Brazil, in 1992 to address serious environmental concerns.

Environmental problems are caused by human beings individually and/or collectively and its solution(s) lies in the hands of same. The development of positive individual attitude towards the environment is perhaps the most important factor in the environmental crusade.

The successful implementation of the plan will require that all sections of the population understand the functioning of the environment and the opportunities and problems it presents in order to take intelligent action towards its protection and improvement.

Since October 1992, the Environmental Protection Agency, (EPA), Ghana, has organised ten (10) institutions, which can reach the community, to prepare an Environmental Education Strategy document for the nation. Eight years later, it is thought expedient to assess the impact of the Environmental Education Strategy on the lifestyle of the people in Ghana; as far as domestic waste management is concerned.

1.2 THE PROBLEM STATEMENT

Domestic Waste Management in most communities in Ghana involves transfer of waste from their point of generation to a disposal site erroneously called landfill sites. In smaller communities, domestic solid wastes are dumped at the outskirts of

the villages. In urban centres, domestic liquid waste flowing in big gutters is sometimes used to irrigate vegetable crops.

Waste recycling is an effective tool used in waste management programmes. The success of this phenomenon depends on the willingness of people to patronise recycled waste products. Besides, the development and adoption of any technology to recycle waste, to a large extent, would be controlled by the usefulness of such technologies.

Whilst the consumption of food and energy from recycled products are indigenous with some group of people, the same could not be said about Ghanaians. A comprehensive study is therefore needed to investigate into the possibility of developing waste recycling procedures to utilise household waste into products for Agricultural productions.

Ho the capital of the Volta region (an urban setting) and Mafi Kumasi (a rural setting) would be used as the case study sites in the research.

CHAPTER TWO

OBJECTIVES

The objectives of the research are to:

- Determine the level of satisfaction in waste management delivery services;
- Assess the perception of people on the consumption of food produced from waste;
- Assess the willingness of people to pay for waste management services;
- Evaluate the possibility of converting domestic waste into compost using the quantity of waste generated in Ho; and
- Determine the economic profitability of compost preparation.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Characteristics of Domestic Waste

2.1.1 Quantity of Domestic Solid Waste

Caincross and Feachem (1993) noted that, the amount of domestic refuse collected varies widely, depending on many factors such as standard of living and living habits. In Europe and North America for instance, it may amount to as much as 2 kg/person/day, but in tropical cities it usually varies between about 0.3 and 1 kg/person/day. Residential waste quantities are determined by population and generation rate. In India, larger communities produce a greater proportion of compostable matter and a lower proportion of ash and fine earth than smaller communities. A daily collection of 0.7 kg/person/day of compostable refuse has been recorded for Bombay, but 0.2-0.35 kg/person/day is more common in small towns and villages.

The quantity of solid waste discarded in a given area will vary by the month and season of the year (Gershan *et al.*, 1986). Agyeiwa (unpublished) summarised her findings in a pilot study of sorting domestic waste at source of generation and it is illustrated in Table 2.1 She found out that high income people produce more waste with high amount of putricible materials.

Table 2.1 Waste generation by low- and medium-income groups.

COMPONENTS	LOW-INCOME CLASS		MEDIUM-INCOME CLASS.	
	DRY	WET	DRY	WET
	SEASON.	SEASON.	SEASON	SEASON
Weight of refuse/person/day.	0.29kg.	0.24kg.	0.47kg.	0.28kg.
Garbage.	79%.	55%.	85%.	82.90%.
Bottle/Glass/Metal.	2.40%.	1.07%.	1.90%.	2.90%.
Ash/Sand/Dust.	12.90%	9.60%.	7.60%.	7.20%.
Paper/Cards/Textiles.	3.30%>	2.380%.	1.90%.	3.30%.
Polythene/Plastics.	2.30%.	2.00%.	3.75%	3.60%.

Source: Agyeiwa (unpublished).

2.1.2 Composition of Domestic Solid Waste

The composition of household refuse also varies. Differences are due to variations in the types of products and services purchased. Regulations such as container deposit law could lower the percentage of glass and metal in household refuse.

A comparative analysis of solid waste characteristics of India (developing country) and Europe (developed country) as quoted in Table 2:2 showed that India produces less but denser refuse per capita than in Europe.

Table 2.2 Approximate composition of town refuse in India compared to Europe.

Characteristics	India	Europe
Paper (%)	2	27
Plastic (%)	1	3
Metals (%)	0.1	7
Glass (%)	0.2	11
Ash & Fine earth (%)	12	16
Rags (%)	3	3
Vegetable matter (%)	75	30
Others (Stones, ceramics, etc) (%)	7	3
Wt. Kg/person/day	0.1-1.0	0.8-2.6
Density kg/l	0.33-0.57	0.13-0.2

Source: Polprasert, 1996

It contains less plastics, metals, glass and paper, which are more prone to be re-used by the urban poor (Caincross and Feacham, 1993). Bulk density of 0.28 kg/l is reported in Thailand (Polprasert, 1996).

2.1.3 Energy Content

As with the other waste characteristics, energy content is community specific and corresponds to variations in composition. The value is based on moisture, ash and inorganic non-combustible materials content. The quantity of solid waste discarded in a community will determine the total amount of energy

available for recovery. Also, the energy content will be subject to seasonal variations (Gersham *et al.*, 1986).

2.1.4 *Liquid Wastes/Domestic Wastewater*

Polprasert (1996) described domestic wastewater as a combination of excreta, flushing water, and other grey water, and is much diluted depending on the per capita water uses. Sullage according to Caincross and Feachem (1993) is domestic wastewater not containing excreta and it is sometimes called grey water in distinction to sewerage or black water.

It should be noted that householders with per capita water consumption less than 100L/day may produce wastewater containing very high solid contents, which could possibly cause sewer blockage. The strength of a wastewater depends mainly on the degree of water dilution, which can be categorised as strong, medium or weak as shown in Table 2.3 (Polprasert, 1996).

Table 2.3 Typical characteristics of domestic wastewater (mg/l).

Parameters	Concentration		
	Strong	Medium	Weak
BOD ₅	400	220	110
COD	1,000	500	250
Org-N	35	15	8
NH ₃ -N	50	25	12
Total N	85	40	20
Total P	15	8	4
Total Solids	1,200	720	350
Suspended Solids	350	220	100

Source: Polprasert (1996)

Table shows that domestic wastewater generally contain sufficient amount of nutrients (based on BOD₅/N/P ratio) suitable for biological waste treatment and recycling where microbial activities are employed.

2.2

General Waste Management Practices

As already noted, waste management according to Baily (1996) covers the planning, operation and maintenance of strategies and systems for the management of materials for which there is no further use. He further describes waste as municipal

municipal solid waste arising from households, municipal and commercial facilities; industrial effluents and sludge. Management was described as minimisation, recovery, recycling, treatment, energy utilization, or collection, treatment and disposal.

Today's widely accepted waste management hierarchy as shown below was based on the model of pollution prevention pays (3P) programme (Bringer, 1992). From an environmental standpoint, source prevention and recycling are preferred over treatment and disposal. What the 3P Programme has evidenced is that in many cases, the waste management hierarchy not only works environmentally but economically as well.

Waste Management: Hierarchy

Source Reduction/Minimisation

Recycle/Reuse

Treatment

Disposal

"The explosive growth of urban population places a huge strain on the ability of governments and municipal agencies to meet the needs of the city dwellers. Urban growth creates demands for housing, transport, water, sanitation, power, education and health facilities. Yet public services typically lack the resources, the skilled managers, the trained personnel and the technical capability..." (Wolfenschn, 1996). The above statements show the challenges facing human communities. It behoves every individual, organization and

institutions to be involved in finding lasting solutions, especially to issues of domestic waste management.

2.2.1 Waste Minimisation

Traditional waste management methods have involved important technical, environmental and/or economic limitations. The scale of these limitations is connected more with the quantity, character and composition of the waste, than the choice of the method of treatment. The reason for this is that waste has been considered and treated as if it were independent of the sources of its production, its scale, and its contents! (Buckman and Lindquist, 1992)

In the case of solid waste, this means that as far as possible the creation of waste must be kept to a minimum. The most fundamental way to reduce waste is to prevent it from ever becoming waste in the first place. By preventive measures, the waste, which is nevertheless created, should not contain environmentally damaging materials and should be prepared for reuse or recycling. This is emphasised by Bringer (1992) that waste reduction in both our processes and our products offers the only hope of coping with the regulatory, litigation and public opinion whirlpool which is steadily increasing in intensity. In addition, there are cost quality and marketing benefits to be obtained.

2.2.2 Resource Recovery.

The reuse of organic material as animal or fish feed, compost or fuel can contribute to the solution of urban problems such as the need for income generation, employment opportunities, food production, the lack of adequate

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disposal sites, energy supply, and maintaining environmental quality. Resource recovery and utilisation are essential elements in any effort to achieve a sustainable level of waste management. Enhancing the recovery of organic waste can restore various natural cycles: thus preventing the loss of new materials, energy and nutrients

An example of an integrated system of urban waste recovery is the multiple use made of waste recovery system as it is operated by the Zabbaleen in Cairo, including pig raising on organic waste, composting of pig manure and garbage and reprocessing of other waste materials such as plastics, is another example of the integrated reuse of organic waste (Lardinois and Kludert, 1994). Basically, in sum, organic material can be reused in three principal ways to improve the soil (compost), to feed animals (fodder) and to produce energy (briquettes, biogas).

2.2.3 Waste Collection, Transportation and Handling.

Waste collection forms a very fundamental, yet a crucial aspect of waste management. The collection of refuse presents peculiar problems as household wastes are thrown out indiscriminately. The removal/collection frequency is determined mainly by the waste decomposition rate and the resulting offensive odour emissions. In tropical cities, since waste may already start to decompose within one or two days, removal/collection is required in most cases on daily basis or at least on alternate days. The different collection system basically include:

- i. Communal storage (bring system), people carry their refuse directly to communal collection points;
- ii. Block collection ("mobile" collection point) where residents carry their waste on prescribed days, time and place to a passing collection vehicle which stops at major intersections only, and
- iii. House-to-house collection, including kerbside (residents carry their waste to the road) and door-to-door collection (collectors enter the courtyard) (Roger and Roland, 1996).

In high-income, low-density suburbs, it is possible to have a covered bin which is emptied once a week or at some appropriate time interval, into a truck. In high-density suburbs, it is not possible to empty individual household bins so that public refuse bins are provided for each group of houses. These are preferably metal bins which are picked up and emptied into a truck with special lifting tackle, or are completely removed and replaced by new ones.

A fleet of appropriate vehicles is necessary to collect the contents of the bins, or pick up the bins themselves. The efficient maintenance and operation of these vehicles is one of the most difficult tasks facing municipalities. The relatively high density of refuse found in low-income communities means that compaction equipment is unnecessary as the collection vehicles. Besides their high purchase cost, sophisticated vehicles produce considerable annual operation and maintenance costs - a factor which must be considered. An agricultural tractor and trailer is often more practical and easier to maintain than many types of purpose-built trucks. Hand and animal-drawn carts, bicycles and tricycles are of course cheaper to buy and more reliable to operate in high-density areas (Roger and Roland, 1996). According to Jain

and Pant (1994), the cost of collection in India tends to be a very large part of overall solid waste budget. He cited the city of Ahmedabad with three million population and 1260 tonnes of solid waste per day which spends 85.8 per cent of its budget on collection, 13.4 per cent on transportation and only 0.8 per cent on final disposal.

Waste treatment near the source of generation and separation at source could be other elements of an integrated approach and an important means of preventing the shift of environmental problems to adjacent urban areas, to urban fringes, to more remote places or to future generations. Composting, at household as well as at neighbourhood level, could be part of such a strategy (Lardinois and Kludert, 1994).

2.2.4 Waste Treatment and Disposal Technologies

In the European Community Directive, waste treatment is defined as waste which has undergone biological, chemical or heat treatment, long-term storage or any other appropriate process so as to significantly reduce its fermentability and the health hazards resulting from its use. Waste disposal to some extent represents the final stage of any treatment sequence, regardless of the detailed technical structure of the sequence. In some cases wastes are disposed without treatment or after treatment. It can be argued that, selection of the best disposal route for domestic waste should start by identifying the most secure and environmentally acceptable final destination for the waste and this, in turn, will dictate the type of treatment required before disposal (Hall, 1992)

Polprasert. (1996), for instance, noted that lime treatment of sludge can inactivate a large number of bacteria and viruses but not helminthic ova. He further noted that an increased destruction of pathogens would also take place if the waste was treated by a biogas or composting system before adding to fish pond, as both processes, especially the latter, lead to an increased temperature which kills pathogens. Hall (1992) reported that the current options potentially available for sludge disposal in the U. K. has been outlined. Agriculture (including horticulture) takes 39%, and other on-land outlets take less than 1%. He however made it clear that while land use (other than agriculture) and minor outlets are on the increase, disposal into marine was to end by 1998. Other treatment and disposal options include incineration, landfilling and pit burial.

2.2.4.1 Composting

Compost is the end product when an organic solid has been stabilised by bacterial action aerobically or anaerobically. Composting is thus the process that converts the organic content of refuse into compost. Compost is a good soil conditioner, which can improve the fertility and structure of agricultural soils. Its agricultural value is greatest if refuse is composted together with suitable quantities of night soil or sludge (Caincross and Feachem, 1993).

As a guide, to supply 50kgN/ha to maize, one needs to apply 5 tons/ha of good quality compost (Ghana/CIDA Grains Dev. Project, 1987). Inge and Arnold (1995) reports that in Bamako Mali, entrepreneurs managed to produce fine

compost naturally by sieving out the impurities and non-organic materials. They earn about three times the minimum wage. The regular supply, the low price, and the proven quality of this soil conditioner have created a high demand, particularly from vegetable farmers in the peri-urban areas.

A variety of more or less mechanised techniques exist for composting. A widely applicable technique is to form long mounds called windrows about 1.5-2m in height. The windrows are turned (either by hand or by tractor shovels) every few days to keep them aerobic and to ensure that all parts of a pile spend some time at the hot centre (Caincross, and Feachem, 1994).

In India, the Karibas and scavengers segregate urban solid waste for mechanised aerobic composting. However, due to low skill/managerial inputs, the operating efficiencies were low resulting in high cost of production. The situation became worse when farmlands became distant from compost production centres thereby making transport cost prohibitive. Farmers also reported problems with broken glass pieces in the compost. A good way to avoid these problems is to intercept suitable wastes at the point of generation before it is mixed with other wastes, concludes Jain and Pant (1994).

Lardinois and van Kludert (1994) again gave an account of a possible negative side effect of composting. They reported that in 1991, a chemical analysis of the compost produced in Cairo showed that it fell below European safety standards; it contained high levels of Zinc (Zn) and lead (Pb) and even dangerous levels of cadmium (Cd). It was assumed that the organic waste was being contaminated by mixing the non-organic, sometimes hazardous waste (such as household batteries), with the organic waste.

2.4.2

Incineration:

This is the burning of refuse. In the United States, most incinerators are not used just to burn trash. The heat derived from the burning is converted into steam and electricity. The newest means of incineration, an European concept, is called mass burn (Edon-D-Enger, and Bradly 1995). In the mass burn technique, municipal solid waste is fed into a furnace, where it falls onto moving grates and is burned at temperatures up to 1300°C. This is used to produce steam, which drives a turbine to generate electricity to be sold to a utility. An advantage of incineration is that it can be carried out relatively close to the centre of a city, thus saving in transport cost (Caincross and Feachem 1994).

Incinerators drastically reduce the amount of municipal solid waste up to 90 per cent by volume and 75 per cent by weight. It is still necessary to dispose of the residue, normally by landfilling. Although its volume and weight is greatly reduced, most plant nutrients in the refuse have been lost so that the residue is of negligible value to agriculture. Many incinerators were eliminated in the North America and Western Europe after 1940 because of aesthetic concerns, such as foul odour, noxious gases, and gritty smoke, rather than for reasons of public health.

Ash from incineration contains varying concentration of toxic substances such as lead (Pb), Cadmium (Cd), mercury (Hg), and arsenic (As) These need to be treated as hazardous waste. Besides the prohibitive cost, critics have argued that cities and towns have impeded waste reduction and recycling efforts by putting a priority on incinerators and committing resources to them. Many communities that have opposed incineration say that they support vigorous waste – reduction and recycling effort.

2.2.4.3

Landfilling/Controlled tipping

A modern sanitary landfill is typically a clay-hued depression in which each day's deposit of fresh garbage is covered with a layer of soil. It is a controlled method of refuse disposal in which refuse is dumped in accordance with a preconceived plan, compacted and covered during and at the end of each day. The nuisance conditions associated with an open dump such as smoke, odour, unsightliness, insect and rodent problems are not present in a properly designed and operated sanitary landfill (Salvato, 1982). It must also provide for gas venting or recovery, prevent groundwater pollution and a leachate collection system. It is technically designed to address most environmental concerns. Currently, about 80 per cent of Municipal solid wastes in North America go into landfill, but this method is failing to handle the volume. Japan and many Western European countries have already moved away from land filling as the primary method because of land scarcities and related environmental concerns.

2.2.4.4

Crude Dumping

Waste may be dumped in some areas so as to reclaim lands, which have been degraded through human activity. Such areas include sand and gravel pits (through winning activities). Depressions and valleys are also used to dump wastes. Areas used for such dumping have not undergone any engineering work to minimise any environmental impact. The wastes too have not been treated in any way. Such dumping grounds pose a threat to underground water and streams and should not be encouraged.

2.4.5

Biogas Extraction (Fermentation)

Biogas, a by-product of anaerobic decomposition of organic matter consists mainly of methane (about 65 per cent), carbon dioxide (about 30 per cent), and trace amounts of ammonia, hydrogen sulphide, and other gases. The energy of biogas originates mainly from methane (CH_4) whose calorific value is 9005 kcal/m^3 at 15.5°C and 1 atmospheric pressure.

The approximate calorific value of biogas produced is $4,450\text{-}6,230 \text{ kcal/m}^3$ (Polprasert, 1996).

Biogas production requires a warm climate; about half as much is produced at 25°C as at 30°C and almost none at all below 15°C (Caincross and Feachem, 1994). The gas is used for domestic cooking and also for powering vehicles, farm machinery, and electric generators. Its initial investment is high and is only appropriate where good maintenance can be guaranteed.

Independently, Pickford (1995) and Caincross *et al.*, (1994) confirmed that in India, China and Korea, a family's excreta supplemented with the dung of three or four cattle or pigs can meet the fuel needs for cooking and lighting of a family of five people.

Exceptionally, a few plants operate with human excreta alone. Few biogas systems are currently available to treat waste of fruits and vegetable origin. Though currently unfeasible as a large-scale option, biogas systems can effectively handle localised and septic waste and contribute to environmentally friendly disposal of waste (Pickford, 1995).

2.2.4.6

Agricultural Lands

Both "nightsoil" and sludge may be used on agricultural lands to enrich the soil. The direct application of nightsoil as an agricultural fertilizer has been practised for centuries in many parts of the world, but the practice involves very substantial health hazards to agricultural workers and to the consumers of the crops grown and it is not recommended. In some countries such as China, the use of human excreta in agriculture is an ancient practice and may provide the main source of fertilizer for the fields. In other countries, such as much of Africa, it is considered much less acceptable to handle human excreta. In China, cartage systems remove excreta from houses and transport them by hand, truck or boat to agricultural areas where they are applied raw to the fields (McGarry and Stainforth, 1978).

2.2.4.7

Water bodies

The discharge of wastewater into the sea, rivers, or streams can result in the self-purification process in which the microbial activities decompose and stabilise the organic compounds present in the wastewater. If there is over-loading of organic waste into the water body, anaerobic condition results and this is detrimental to aquatic organisms (Polprasert, 1996).

Ponds containing human wastes are rich in aquatic life provided they remain in aerobic condition. In particular, this supports large blooms of algae. These conditions are perfect for the growth of certain types of fish, especially carp and tilapia. Ducks also thrive in conjunction with fish in such ponds (Caincross and Feachem, 1994).

Irrigation with wastewater has benefits for areas that are permanently or seasonally arid. Sewage from the city of Kampur was mixed with equal volumes of diluting water and spread across over 1400 hectares. Crop yields from the land on which sewage is spread are much higher than those from land irrigated with clean water.

2.3 Waste as Resource

Domestic refuse provides a lot of valuable materials, which could be recycled into useful products. Components of domestic wastes could be substituted for natural resources thereby helping to conserve both renewable and non-renewable resources. The materials, which are most suitable for recycling, are glasses (cullet), plastic (thermoplastics) scrap iron, non-ferrous metals, paper and textiles (Edon-D-Enger, and Bradly 1995)

In order to prevent the spread of disease, it is not practicable to sell waste food, except on an industrial scale. Composting, however, is an alternative. Human or animal excreta contain nutrients like those in artificial fertilizers and therefore could be incorporated into composts. They contain all the trace elements required by plants unlike artificial fertilizers. Compost encourages the formation of humus, which is essential for optimum soil structure and water retention. They also promote microbial life and the conversion of minerals to biologically active forms (Pickford, 1995).

Physical Closing of Natural Cycles

The first initial principle of an ecosystem is that its components interact together in many complex ways as shown in Fig. 2.1. below, the situation is very complex, as in each part of any ecosystem there are innumerable species or equivalent components, which interact.

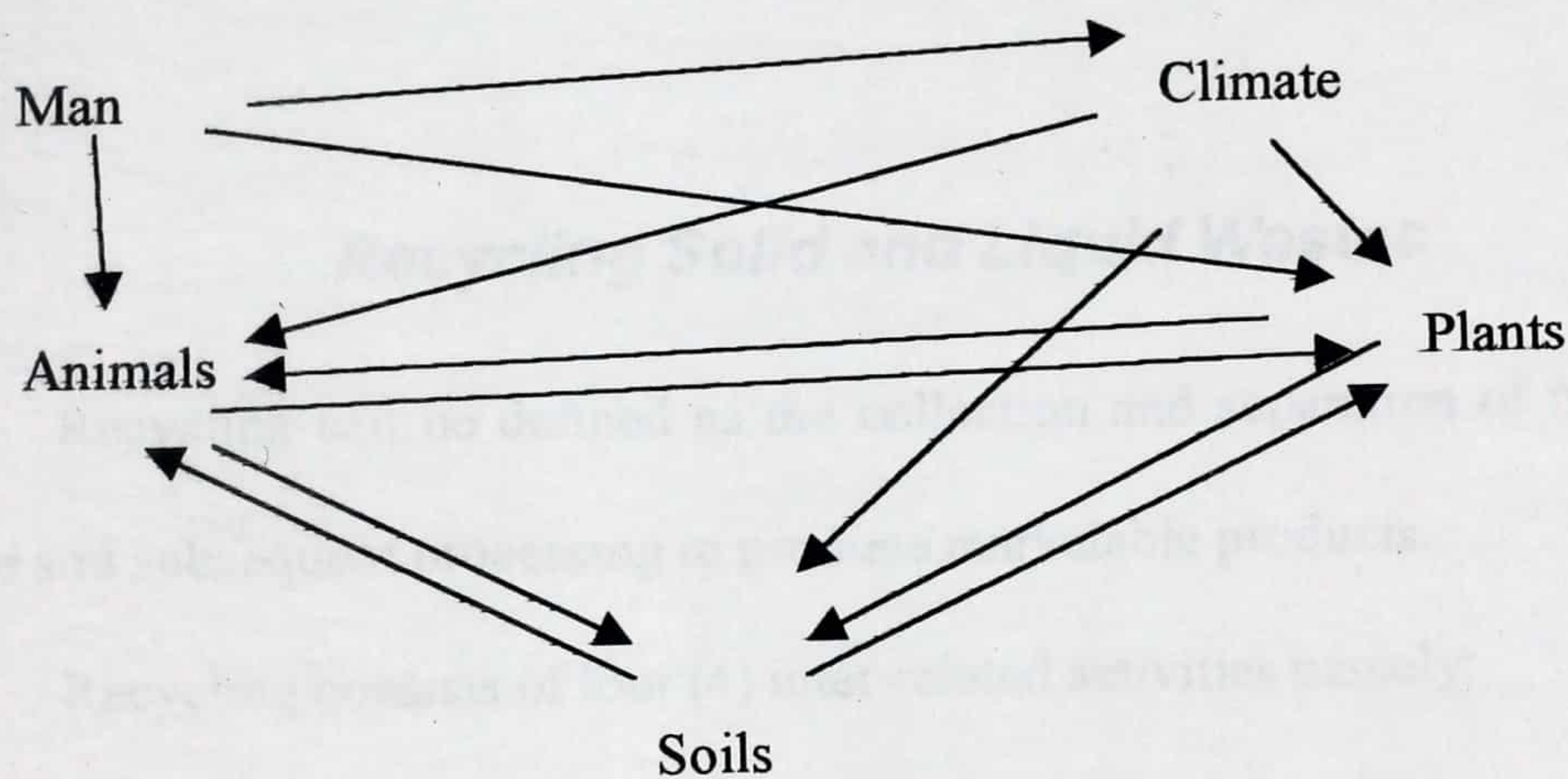


Fig.2.1 The components of an ecosystem and the interactions between them

The stability that appears in nature is therefore not the outcome of a static situation, but of a dynamic equilibrium. As a result, radical changes in an ecosystem can occur even if only one small component is disturbed.

The second essential principle is that the components of an ecosystem are linked together by a flow and cycling of materials. Materials and Energy cycle between one component and another. Without this transfer, growth in the ecosystem would be impossible.

The third principle, which of course applies to all matter but which was first pointed out with great advocacy by Commoner (1971) to be particularly important when wastes are being disposed of, is that 'everything must go somewhere'. It is very easy to get rid of waste into the environment with the belief that it will just disappear. This may apparently do, but the material or its components must actually move through ecosystems and end up in definable situations, where problems may arise.

2.3.2 Recycling Solid and Liquid Wastes

Recycling can be defined as the collection and separation of materials from waste and subsequent processing to produce marketable products.

Recycling consists of four (4) inter-related activities namely:

- Collection and transport of the waste;
- Separation and clean-up
- Processing to obtain marketable materials and products; and
- Marketing of the products.

Some of the marketable products include:

- Materials such as paper and board,
- Finished products partly or totally consisting recycled materials
- Fuel-solid, liquid or gaseous
- Energy-heat or electricity, and
- Compost.

The success of recycling schemes depends critically on economics. The economics of a scheme depends in turn on the way in which these different stages interact. For instance, separating materials early in the waste stream is likely to yield less contaminated materials but it is also likely to be more expensive (Recycling, 1991).

Jain and Pant (1994) pointed out that the 3R's of waste management namely Reduce, Recycle, and Recover are often repeated phrases in Indian policy circles. Table 2.4 summarises the utilization of rural wastes for various end uses in India.

Table 2.4. Percentage utilization of rural wastes for various end uses:

<u>End Use</u>	<u>Percentage Utilization</u>
Fuel	14.8
Animal feed	35.0
Farm manure	39.4
Construction material	2.8
Industrial raw material	1.5
Other uses	4.9
Waste	1.6

Sewerage sludge requires safe and economical disposal, and recycling to farmland has long been the natural and most important method. As the need developed for the reuse of water from rivers, higher standards of effluent treatment were required and consequently more sewerage sludge was produced.

2.3.2.1 *Benefits of Recycling*

Some benefits of recycling are readily recognizable, such as conservation of resources and pollution reduction.

In the first place, recycling reduces the amount of energy required for manufacturing. Recycling crushed glass (cullet) for instance reduces the energy requirement by 50 per cent. Also, to recycle aluminium for example, uses approximately one twentieth as much energy as producing new aluminium from one (Baily, 1996).

Edon-D-Enger, and Bradly (1995) summarised the benefits of a national bottle bill by saying that it would reduce litter, save energy and money, create jobs and also conserve natural resources. He pointed out that, metric tons of glass, 2 million metric tonnes of steel and 0.5 million metric tons of aluminium a national container bill could save approximately 7 million each year. In Panji, India, a large number of waste pickers make their livelihood by collecting a variety of recyclable wastes from bins and the disposal site (Selvan, 1994). In Ghana, waste pickers visit dumpsites to pick containers and metallic materials to sell to those who need them.

Jain and Pant (1994) contends that composting is a highly suitable option for urban solid waste in India. The idea of composting is appealing as it helps to recycle the nutrients back to the land. Energy can also be obtained from refuse-derived fuels in the form of biogas and pelletised combustibles. The large scale processing of garbage was also to slow down exhaustion of landfill space considerably in the near city, obviating the need to spend much larger amounts on transportation cost.

Finally, recycling helps to conserve foreign exchange since waste materials will help to save raw materials and reduce dependency on imports. In the United States for instance, 91% of aluminium is recycled annually (Edon-D-Enger and Bradly, 1995).

2.3.2.2 Barriers to Recycling

The two main barriers to recycling are the technical one of contamination and the economic one of market supply and demand.

Technically, household wastes are mixtures of potentially reclaimable materials and gross contamination. Besides waste materials do not conform to specification; it is necessary to either remove the contaminations or to dilute them with materials having low contaminant levels.

In economic terms recycled materials compete greatly with primary materials in terms of price and quality of products. Also, demand for materials is dependent on the level of industrial activity, which is clearly cyclical. As supply and demand change the price of primary raw materials change, which in turn affects the price of recycled materials.

2.4

WASTE MANAGEMENT STRATEGIES

2.4.1

Planning

A potentially very valuable tool in establishing a co-ordinated response to strategic environmental problems is the preparation of environmental action plans or strategies. Depending on the particular circumstances, such strategic planning initiatives may precede or follow EIA studies. Strategic Environmental Assessment may form part of the strategic planning process.

Traditional approaches and concepts in planning have emphasized rigid plans for controlling and guiding future development patterns. Planning has become more of a continuous process, suitable to changing circumstances and long-term targets. Most environmental management plans not only set objectives, but also identify actions to be taken, prioritised to ensure that scarce resources can be effectively allocated. Monitoring and reviews say every year or every five years are used to keep the plan topical and relevant.

Examples of various environmental management planning initiatives are National Environmental Action Plans (NEAP), Urban (Area) Action Plan, Waste Disposal Strategy, Coastal Zone Management Plan and Catchment Management Plan. In general terms, a local waste strategy will need to comply with the principles set at national level. In preparing a local waste plan, detailed consideration should be given to factors such as waste minimisation, recycling, recovery, collection, treatment, disposal to landfill, environmental effects regulation and targets.

2.4.2

Institutional Development

The viability of resource recovery systems depends upon a number of important technical, socio-economic and political relationships. A strategy or approach to be developed, either regional or grassroots, to lay the foundations of work. As already noted under 2.2, recycling programmes concern an institutional arrangement between the government agencies, municipalities, etc. The municipality must cooperate with government for the promotion and implementation of planning programmes; co-operatives or districts should be established to be directly involved in construction, operation, and maintenance of recycling facilities, if there are any.

The development and application of science and technology should be conducive to waste recycling. Furthermore a policy that takes into account the natural, economic, and social characteristic of each region or locality, if taken widely, would secure more co-operation in creating recycling policy (Polprasert, 1996).

In the past, many municipalities opted for capital – intensive solutions to the waste problem, such as buying large-scale mechanical composting plants rather than developing small-scale, low-tech and low-cost approaches. This is not surprising since the installation of a plant is an easy decision for a city council, especially, if it is offered as a gift or on low-interest financing under a bilateral agreement. Also, a people centred approach requires much more elaborate and decentralised decision-making and co-ordination.

... A prerequisite for well-functioning organic waste recovery activities is the co-operation between government and private initiator. The wake of

democratisation processes all over the world facilitates the cooperation between public authorities and private initiatives. This is clearly shown by the Bamako case. Micro-entrepreneurs not only make and sell compost at the dumpsites, but several private enterprises and non-governmental organizations have also started waste collection and treatment services. However, to maintain public health and environmental standards the final responsibility (e.g. Legislation, co-ordination, and control of private services) for waste collection, treatment and disposal should rest with the government (Lardinois and van der Kludert, 1994).

According to Kobieh (1997) Deputy Minister for Local Government and Rural Development, the major factors hampering the development, management and maintenance of sound environmental sanitation are the fragmentation of the responsibility for environmental sanitation among several ministries and agencies causing disjointed and uncoordinated planning, management of programmes and services.

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2.4.3 Community Participation

A group of people, whether living in a few isolated dwellings, or in a village, or in part of a town or city, may already have or develop a cohesiveness that justifies the title 'community'. The sense of community is increased by carrying out some activity together and by participating in joint ventures. Community participation was encouraged in Trinidad and Tobago by inviting members of the public to propose slogans on ways of improving environmental

health. It was claimed that the increase of latrine use in Bangladesh from 4 percent to 25 percent between 1985 to 1992 was due to motivation programmes based on privacy, convenience, comfort of women and prestige rather than health (Pickford, 1995).

An impressive level of commitment is demonstrated by the Bolivian Community teams, which are composed of residents varying in age, occupation, and education level. They work enthusiastically without pay evenings and weekends to make decisions and plans for community action (Hall, 1992). The involvement and participation of local residents in urban planning and management can create cheap and effective local solutions to fit local needs and opportunities. In the area of solid waste management for example, if traditional municipal resources such as garbage trucks are insufficient, different collection methods can be evolved for different types of settlements. The handcarts and dumpsite scavengers are a possibility, and they must be seen as an important resource, rather than as a nuisance or an eyesore (Wanyeki, 1996).

On a survey conducted on behalf of Volta Rural Water Supply and Sanitation Project, Amoah (1996) noted that, the success of small-scale water and sanitation projects is dependent on a number of factors including strategic geographical capabilities of beneficiary communities. However, the demand-driven approach has revealed that there are relative differences in the financial capabilities of communities. This affects the level of participation.

In a recent publication, the World Bank states that “more than natural resources, more than cheap labour, more than financial capital, knowledge is becoming the key factor in production (CTA, 1994). Hence, the importance of education cannot be overemphasised.

Education tends to emphasise the transmission of knowledge, through a number of disconnected channels, which are often narrowly focused. Thus Environmental Education has consisted of imposing a message or messages about the environment and its sustainability. In its mission statement, the EPA, Ghana hopes to assist the institutions responsible for education in Ghana (media, formal and non-formal) to assume responsibility for the delivery of Environmental Education as a legitimate aspect of their activities (Ghana EPA, 1995).

The success of any educational activity depends on the effectiveness of the communication system. As noted by Mckee (1994), bringing about a “sanitary revolution” means bringing about a “communication revolution”. He contended that in a few countries, this process has begun using a three-pronged strategy of advocacy, social mobilization and programme communication. In the case of sanitation in Bangladesh, the relationship between strategies was modeled as shown in Fig. 2.2

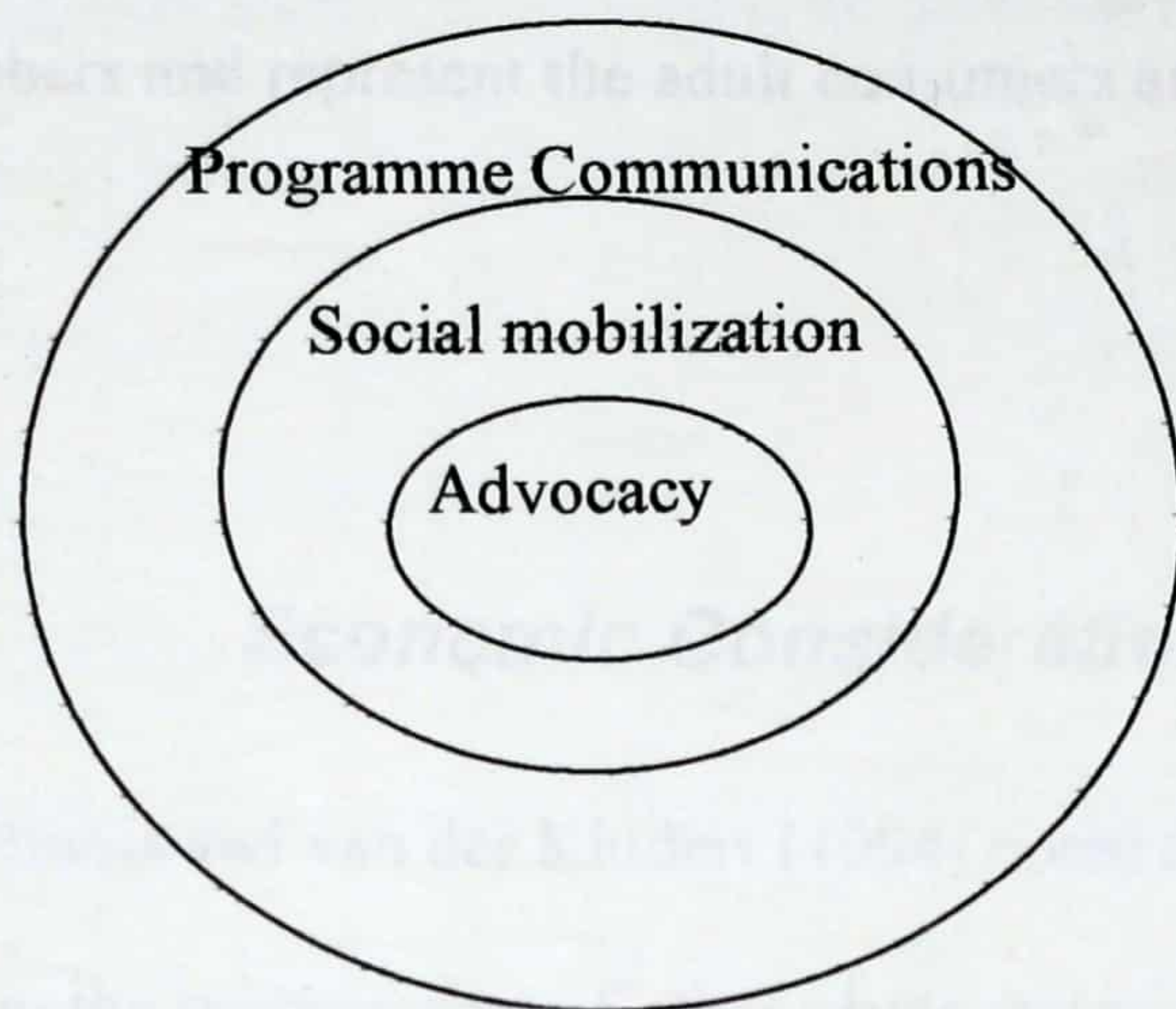


Fig. 2.2 Sanitation for All in Bangladesh.

Education as already noted is very important in implementing a waste management strategy. A sound education requires well-trained and motivated staff who will carry out the assignment. The educational plan should ensure that individuals are exposed to the messages about the scheme on a regular, systematic basis.

Ideally, an educational plan should be prepared in the following sequence:

- Develop the message
- Identify the audience, and
- Select publicity and educational methods.

The audience can be identified by dividing the community into sectors. Target audiences will include school children, retailers, employees, employers, professional organizations, voluntary and church groups, and recreational clubs. Education authorities can play very crucial roles; perhaps the most important audience to reach is school children. School children are a key group both because they are responsive and

because they are responsive and because they are influential – they influence other family members and represent the adult consumers and waste creators tomorrow.

2.4.5 *Economic Consideration*

Lardinois and van der Kludert (1994) noted that the recovery of organic waste differs from the reprocessing of other waste materials such as plastics and rubber in that the latter have proven their economic profitability in small-scale enterprises. An account of composting by a marginalized group, the Zabbaleen in Cairo revealed that 30 tonnes per shift per day of compost could be prepared from waste and pig manure. The compost is sold mostly to farmers within a radius of 100/150 km around Cairo, who also pay the transport cost. The operating costs and also part of some welfare projects are paid for from the sale of the compost. They however contend that not all organic waste processing activities are cost effective. One of the bottlenecks in organic waste processing is the marketing of end products, compost. High transportation costs limit the use of compost to the surrounding areas of the city. They believe urban agriculture and urban 'greening' could be an option for the application of large amounts of organic waste. They concluded that there is a conflict between the financial constraints and the ecological advantages of resource recovery of organic waste material. Large-scale composting activities also in industrialised countries, have shown that environmental benefits are more realistic targets than economic feasibility.

The process of economic appraisal of any waste management system takes into account both immediate and future costs and benefits using discounting as the means

of comparing costs and benefits which accrue at different times. Immediate profit should not be schemes except in large metropolitan authorities where pressures on landfill sites means that waste disposal cost are already high.

Waste management authorities are unlikely to be able to attempt a full cost-benefit analysis (by putting values on them). But it will be helpful to list the wider environmental impacts and to consider whether they tip the balance of the decision so that the authority may be willing to bear a financial loss in order to generate wider benefits

Recycling makes financial sense if the total net financial cost of the recycling and disposal option is, less than the financial cost of the least cost disposal option. This is more likely to be the case the higher the cost of disposal incurred by the waste disposal authority.

Standard economic analysis is based on an efficiency criterion, which suggests that because recycling activities are not themselves costless, technically feasible recycling should take place up to the point at which total social benefits exceed total social costs by a maximum amount. Economic efficiency therefore has to do with obtaining the greatest value of real output for a given input cost, or alternatively achieving a given value of real output at minimum input cost. The concept of social cost or benefit encompasses both the financial costs of, or revenues derived from, a recycling scheme and any environmental cost or benefit. Quantified social costs and benefits should then all be placed on a monetary scale of value.

Waste disposal authorities need not be required to prove the financial profitability of any recycling scheme, but merely that the introduction of such a

scheme into the waste management system has reduced the overall net social costs of the system. The authorities have a statutory duty to collect and dispose of municipal waste, and so it is the relative costs of recycling compared with waste collection and disposal that is significant.

We can now itemize, in more formal way, both the benefits of recycling (in terms of the avoided costs of the disposal option) and the cost of recycling.

$$\text{Benefits of recycling} = \text{BR} = V_C + V_P + S_K$$

$$\text{or BR} = \text{SCP} + \text{SCD where}$$

V_C = Primary cost of material extraction (extraction cost + user costs);

V_P = Population/environmental cost of primary material extraction/harvest and processing.

S_K = Cost of collection for disposal purposes, and the cost of disposal

SCP = Total social costs of primary material use.

SCD = Total social costs of collection and disposal system without the recycling option.

Cost of recycling = $\text{SCS} = S_{KR} + S_{ST} + S_P$, where;

S_{KR} = Cost of collection for recycling purposes.

S_{ST} = cost of separation, processing and transportation of recycled materials.

S_P = Production cost of recycling, and

SCS = Total cost of recycling activity.

Hence, net benefits of recycling, NBR , are given by:

$$\text{NBR} = \text{SCV} + \text{SCD} - \text{SCS}.$$

This general formula now needs to be adopted to take into account;

1. Different alternative physical recycling system configurations (i.e. source separation scheme variants or centralised, mechanical separation plant variants);
2. Different recyclable materials, paper, glass, aluminium, triplate/steel, and plastic.

Evaluating a resource recovery facility (mechanical separation) would need to be undertaken on the basis (given data that are currently available in a monetary form) by calculating the Present Value of the Option's Net Benefit, NPV given by:

$$NPV = \sum_{t=0}^{t=T} K + \frac{Bt - Vc_1}{(1+r)^t}, \quad \text{where}$$

K = capital cost;

Bt = benefits derived over time;

Vc₁ = operating costs over time;

r = discount rate

T = project lifetime

NPV = net present value of net disposal costs.

Table 2.5 Financial and Economic Accounting in the context of hypothetical resource recovery facility.

FINANCIAL ACCOUNTING	ECONOMIC ACCOUNTING
1. Capital cost (fixed)	1. Capital cost
2. Interest of capital	2. Operational cost ($S_{Kt} - S_{St}$)
3. Operation cost	3. Cost of residual waste disposal ($R_{SD}) - (R_{SDP})$
4. Cost of residual waste disposal	4. External cost, pollution etc. (S_P)
5. Total cost	5. Total social cost
6. Revenues	6. Revenues
7. Net revenues or cost	7. External benefits ($V_F + S_D + V_P$)
8. Net profit or loss per ton.	8. Net social benefits or cost
9. Discounted cash flow over time	9. Net economic return or loss per tonne.
10. Compare with net cost of alternative disposal option i.e. landfill	Discounted net present value. 10. Compare with net social cost if alternative disposal option i.e. landfill.

2.5.0 Public Health

2.5.1 Health Aspects Associated with Solid Waste

Poor refuse disposal will encourage fly breeding and may thus promote the transmission of faecal-oral infections. It can also promote diseases associated with rats

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such as dengue, leptospirosis, salmonellosis, endemic typhus and rat-bite ulcer.

Uncontrolled refuse can obstruct streets and drainage channels.

Disease risks associated with composting result from:

- 1 The Pathogen that are normally present in the raw wastes (called primary pathogens) and
- 2 Fungi and actinomycetes that grow during composting (called secondary pathogens).

The primary pathogens such as bacteria, viruses, protozoa, and helminths can initiate an infection in healthy individuals, while secondary pathogens usually infect people with debilitated immune system (U.S. EPA, 1981). Some of the diseases associated with these pathogens, as already noted, include amoebic dysentery, salmonellosis, ascariasis, infectious hepatitis, and aspergillosis. These pathogens are likely to be transferred to crops when the compost is applied to the field thus posing danger to both the farmers and the consumers of the crop.

Epidemiological study conducted on compost users in USA revealed that nose and throat cultures positive for *Asperigilus fumigatus* were more common for these compost workers than for others. Therefore skin contact with the compost materials should be avoided and proper measures – such as wearing gloves, boots and masks – should be taken to prevent the inhalation of the spores of secondary pathogens, especially during the turning of compost piles (Caincross and Feachem, 1994).

2.5.2

Health Risks Associated with Liquid Wastes

Discharge of wastewater and sewage directly into streams/canals, dumping of garbage and defecation of low-income communities on canal banks, open lands, etc. which end up in canal system in the rainy season pollute them. The effects due to pollution can be categorised as:

- 1 Effect on human health by bathing and washing in the polluted water
- 2 Effect on human health from mosquito borne diseases associated with stagnant or low flow water.
- 3 Accumulation of toxic pollutants in fish and other aquatic organisms, and
- 4 Accumulation of toxins in the food chain.

Irrigation with sewage entails risk of disease spreading that varies with the type of crops. Farm workers are at risk with all crops. With crops grown for fodder including pasture, those who consume meat are also at risk. With industrial crops such as sisal, risk extends to product handlers. Crops eaten raw present the greatest risk, especially plant near the soil (like lettuce) and root crops like radish and onions. The growing time of salad crops is often shorter than the survival time of pathogens. So irrigation with sewage (or spreading untreated human excreta) is potentially harmful even when it takes place before planting.

To overcome these health hazards full treatment of wastes should be combined judiciously with:

- careful choice of the method of application to crops,
- crop restriction, and

- human exposure control (wearing protective clothing's, immunisation and deworming).

As organic wastes such as sludge and animal manure can contain a large number of pathogens, fish rearing in a waste-fed pond obviously carries a risk of contamination with these pathogens. According to Feachem *et al*, (1983), three distinct health problems associated with fish culture in ponds enriched with human and/or animal wastes are:

- the passive transference of pathogens by fish which become contaminated in polluted water;
- the transmission of certain helminths whose life cycle include fish as an intermediate host; and
- the transmission of other helminths with a life cycle involving other pond fauna, such as snail hosts of schistosomes.

The first problem is a cause of concern worldwide, whereas the second and third apply only in areas where the helminths concerned are endemic.

A way to overcome this public health problem, perhaps is to treat the waste prior to use in fish culture to meet the WHO standards for aquacultural reuse. An increased destruction of pathogens would take place if the waste was treated by a biogas or composting system before adding to the fish pond, as both processes, especially the latter, lead to an increased temperature which kills the pathogens. An additional step could involve depuration, the maintenance of the fish in clean water for a week or two, which may eliminate the disease organisms surviving earlier treatments. Also, there should be a good hygiene at all stages of fish handling and

processing and to ensure that fish intestines are removed, and that the meat is thoroughly washed and cooked, before consumption. Another strategy could involve feeding a waste grown fish to other animals, which can be consumed by humans so that the fish raised on waste are not consumed directly by humans.

Alternatively, algae and duckweed grown in wastewater are harvested and fed to cattle, poultry, pigs or fish or composted to provide fertilizer (Polprasert, 1996).

2.6 Socio-cultural Implications

The feasibility of a waste-recycling scheme depends not only on technical aspects but also on social, cultural, public health, and institutional considerations. A social survey findings form an important basis for the development of a sustainable solid waste management system (Selvan, 1994). It has been noted that, although waste recycling has been in practice successfully in many countries (both developed and developing), a large number of people still lack understanding and neglect the benefits to be gained from these waste recycling schemes. As the success of any program depends greatly on public acceptance, the communities and people concerned should be made aware of the waste recycling programs to be implemented, their processes, advantages and disadvantages (Polpersert, 1996).

In several African, American and European societies, a human excreta is regarded as repugnant substances best kept away from the sense of sight and smell. Therefore, products, which come into direct or indirect contact with excreta is likely to be considered tainted or defiled in some way. In contrast, both human and animal

wastes have been used in aquaculture in countries such as China, Japan, and Indonesia. In such societies, intense cultivation practices have evolved in response to the need of feeding a large number of people living in an area of limited land availability, and calling for careful use of all resources available to the community including excreta (WHO, 1989).

Cultural beliefs vary so widely in different parts of the world. It is therefore not possible to assume that existing practices can be readily transferred elsewhere

2.6.1 Public Perception on Food

A number of surveys carried out in the U.K. and in Europe indicate that there are three important areas of consumer concern with regard to food:

- i. the healthiness of food in general is now a significant attribute contributing to the consumer perception of quality of diet,
- ii. there is a concern over the risk of contamination of food by residues of agrochemicals, and
- iii. there is a widespread concern over the quality of the environment and the negative impact of modern agricultural systems on the countryside (Lampkin, 1994).

Lampkin (1994) noted that, there was undoubtedly a general concern about the health attributes of food. Seventy-five per cent of respondents in a survey of 500 food shoppers in three Berkshire towns agreed that people should be more concerned about

what they eat, while only slightly fewer (69%) felt that this concern should be reflected among food manufacturers when formulating their products.

Sixty-five per cent of respondents in the Elm Farm Research Centre (EFRC) survey felt that residues of agrochemicals were increasingly appearing in food. The presence of agrochemical residues on fresh produce came second only to the general concern over diet and health for the majority of consumers questioned.

Turning to the impact of agriculture on the environment, 60% of respondents in the EFRC survey agreed with the statement: 'the countryside and the environment are being destroyed by today's farming methods'. In West Germany, 99% of the respondents considered that agricultural land was environmentally damaged. In a survey of 2,206 consumers throughout Germany, 86% of the total population associated the words 'environmental protection' with organic agriculture, while 30% of the respondents were frequently concerned that foodstuffs contain substances which are harmful to people (Lampkin, 1994).

The Allensbacher Institute survey on the positive and negative attributes of organic food found out that 57% of the total population considered organic food to be more healthy, while 45% considered that there were higher levels of nutrients and vitamins in organic as compared to conventional food. Thirty-four percent considered that organic food was more tasty. One of the most important conclusions that emerged was that consumers did not necessarily, expect organic produce to be 'residue-free' and were all aware of the problems created by general environmental contamination by pesticides. Out of 1,013 British housewives interviewed on healthy foods and healthy eating, 75% of the respondents agreed with the statement that all food should

be grown organically without chemical fertilizers. Almost the same proportion (72%) accepted that food produced without chemical fertilizers would be more expensive (Lampkin, 1994)

A major problem relating to the consumption of fish raised on wastes is the public acceptability of the fish. As far as taste and texture are concerned, observations by various workers indicate that fish grown in well-treated domestic waste are equal to, or even superior in taste or odour to non-wastewater cultivated fish. Fish grown in manure-fed ponds have a different taste and texture as they are much leaner, with only 6% fat, which is excellent compared with fish raised on high protein feed pellets with 15% fat, and fish raised on grain with 20% (Allen and Hephew, 1976).

There appears to be definite cultural differences concerning the consumption of fish reared on human wastes (Edwards, 1980). Chinese and Indians appear to have few objections to eating, whereas Malays and Thais immediately reject such a suggestion. Muslims would also reject fish grown on some waste, as it is religiously unclean to them. Edwards (1980) suggested that indirect reuse of excreta for food production could become of relevance to societies where direct reuse is socially unacceptable. Indirect reuse of excreta via duckweed may be of relevance to societies where direct reuse is socially unacceptable. Similarly, the mainly Islamic villagers in Bangladesh initially rejected fish fed on duckweed-grown ponds fertilised with latrine effluents. Resistance however, decreased with time.

CHAPTER THREE

3.0 RESEARCH APPROACH AND METHODOLOGY

3.1 *Selection of study area*

Waste generation and its subsequent management is a matter of concern to all human settlements. The gravity of the problem is more intense in urban communities but the earlier a solution is found in all communities, the better. In view of this, Ho, an urban area, which is also a regional capital, and Mafi Kumasi area, a rural area, were chosen (Appendix 4). Both areas have features similar to any urban and rural setting in Ghana. The area is basically chosen for ease of effective communication to all categories of people residing in the area. The study area is predominantly Ewe speaking communities.

Indigenous Ho consists of a number of suburbs and the main ones are Bankoe, Dome, Aho, Hliha, Heve and Fiave. Other areas, which are somehow considered to be high-class residential area, include SSNIT Flats, Mawuli Estate, New Housing Estates, and the Residency (Appendix 5). Indigenous Ho lacks proper planning hence most of the facilities and social services are currently under stress. Currently, rubbish containers are deposited at vantage points for residents to deposit their household refuse for collection and disposal by the District Assembly.

3.2

BACKGROUND OF STUDY AREA.

An urban community (Ho) and a rural setting (Mafi Kumasi area) were chosen for the studies.

Study Method and Data Collection.

Ho is the capital of Volta Region in Ghana. It is an important administrative, commercial and employment centre with an annual population growth rate of 3.2%.

The table below shows the present and projected population of the Ho metropolitan area from 1970 up to 2005 AD.

Table 3.1 Population projection of Ho.

Year	1970	1984	1994	1995	2000	2005
Population	24,199	37,777	52,000	53,000	63,000	73,000

Computed from Ghana Population Census Report (Vol. 11, 1960)

Apart from commercial activities, most of the people in Ho are farmers and there are a lot of farming communities surrounding the town. An agricultural project known as Volta Region Agricultural Development Project was launched in the region in 1982. This project has created awareness in improved methods of farming especially in fertilizer application, planting in rows and post-harvest loss control.

Mafi Kumasi and its surrounding villages are renowned farming area in the North Tongu District of the Volta Region. The area is noted for gari processing (a product of cassava) and the cultivation of other crops such as maize, groundnut, pepper etc.

3.3 Study Method and Data Collection.

Data used in this study were obtained from two main sources: primary and secondary. The primary sources involved field survey (Rapid Appraisal and Sample Survey). The secondary sources included a review of existing literature on the study area in relation to districts, regions, and nations since waste management knows no political boundary.

Two approaches were thus used in the conduct of the study. These are:

- (i) Exploratory/Familiarisation visits
- (ii) Administration of content validated questionnaires.

3.3.1 Exploratory/Familiarisation Visit

Three (3) weeks were taken to visit the various divisions and other settlement areas in the municipality to acquaint oneself with waste disposal situation in the various communities. Distributions of waste disposal facilities were taken note of. Care was taken to identify possible places where questionnaires will be administered. Another one (1) week was taken to visit the rural communities to assess the population size.

The objectives of this survey were:

- To establish rapport with officials at the District Assembly, the main authority responsible for disposal. Unit committee members were also contacted and informed about the study.

- To pre-test questionnaires to be used in the actual survey, and
- To rapidly appraise some socio-economic features in the area.

3.3.2 Questionnaire Administration.

Two assistants were trained to assist in the administration of questionnaires.

Survey systems ignore total populations. A 0.003% of a large population can be used to represent views of a total population (Internet).

Questionnaires were administered to one hundred and fifty (150) residents; representing 0.024% of the population in Ho. Questionnaires was randomly administered in all the divisions of the area. Fifteen (15) Assemblymen, representatives of the people at the grassroot level, were also interviewed.

In Mafi Kumasi area, eighty (80) questionnaires; representing 2.2% of the population were again randomly administered. The questionnaire was administered randomly so as to get a general perception on waste management and reuse. The administration of the questionnaire took about four (4) months to complete. The questionnaires were serially numbered to ease analysis.

3.4 Data Analysis.

Data gathered through the rapid appraisal technique have been analysed qualitatively. On the other hand, responses of the respondents have been analysed

quantitatively. The number of times a particular response was given was scored and fed into the computer. The figures were statistically analysed using the Statistical Package for Social Scientists (SPSS) programme. The programme analyses data into percentages, frequencies, means, etc.

Data in the study area have, thus been analysed quantitatively and qualitatively. This approach was made for simplification, easy understanding and interpretation of data. Some of the results that were obtained were transformed into tables and figures.

CHAPTER FOUR

4.1. General Sanitation Situation

Personal observation revealed that general sanitation has improved remarkably over the past two (2) years in Ho. As shown in Table 4.1 responses from the urban population indicate that 24 per cent were fully satisfied with the services of the District Assembly while 66 percent were partially satisfied and 10 per cent were however not satisfied at all.

Table 4.1 Satisfaction level for waste disposal in Ho.

Satisfaction Level.	Percentages
Fully Satisfied.	24.
Partially Satisfied.	66.
Not Satisfied.	10.

This positive assertion was made because a few years ago “mountains” of refuse were found at many areas in the municipality, but this is now non-existent. Unsightly areas include undeveloped building plots. Overgrown bushes in these areas trap air-blown papers and polythene sheets. Lazy children also empty their litterbins in these bushes.

Ho has a good natural drainage system. Even though many parts of the municipality are not having constructed drains, water-flow is quite swift to carry away most organic and inorganic materials especially in the raining season.

The frequency of removal of waste containers from temporal storage/collection points by the District Assembly is also not too bad, but could be improved. The few public KVIP toilets are manned by private people and are fairly well cared for.

Nonetheless, the provision of sanitary facilities is woefully inadequate. Consequence upon the banning of pan latrine in the Ho municipality in 1992, many of the residents rely on public KVIP latrine. Ever since, there has not been any additional KVIP put up even though the population has increased. A visit to toilet site reveals that people are always waiting for others to have their turn (Plate 1).



Platel. People waiting by KVIP to have their turn.

In addition, the supply and distribution of refuse containers by the District Assembly leaves much to be desired. The whole Ho township is being served by twelve (12) containers. Their distribution excludes others from having access to them. The relatively far distance of the containers from some residents encourages lazy children to deposit the refuse into undeveloped bushy building plots. Furthermore, the design of the containers is such that some children cannot easily deposit their refuse directly into them. This creates unsightly scenes as well as more work for the



Plate 2 Picture showing unsightly scene around container.

labourers to do (Plate 2). The final disposal site is a mere dumping ground, four (4) kilometres away from the town, where fire is set to the refuse in the dry season. Sewage collected in cesspool tankers are also deposited about 5km from the town.

4.2 Waste Collection, Handling and Transport on Compost Preparation

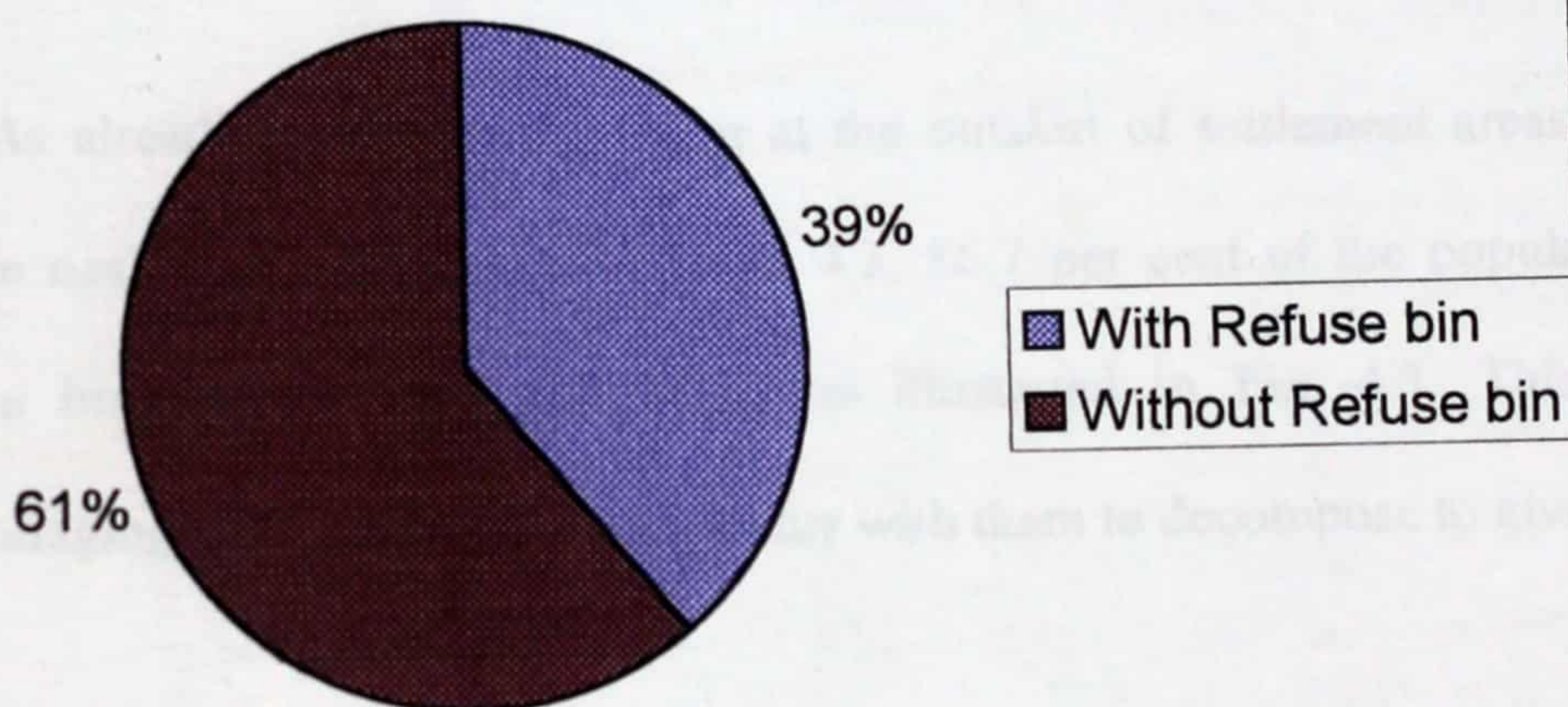
Refuse collection in individual homes is very crucial in the entire waste management system. Majority of the population, 60.9 per cent, use refuse bin in the study area (Fig. 4.1). Table 4.2 shows the percentages of the urban and rural populations having refuse bins. A greater proportion of the urban population, 80 per cent, have refuse bins as against 20 per cent who do not have (Fig. 4.2).

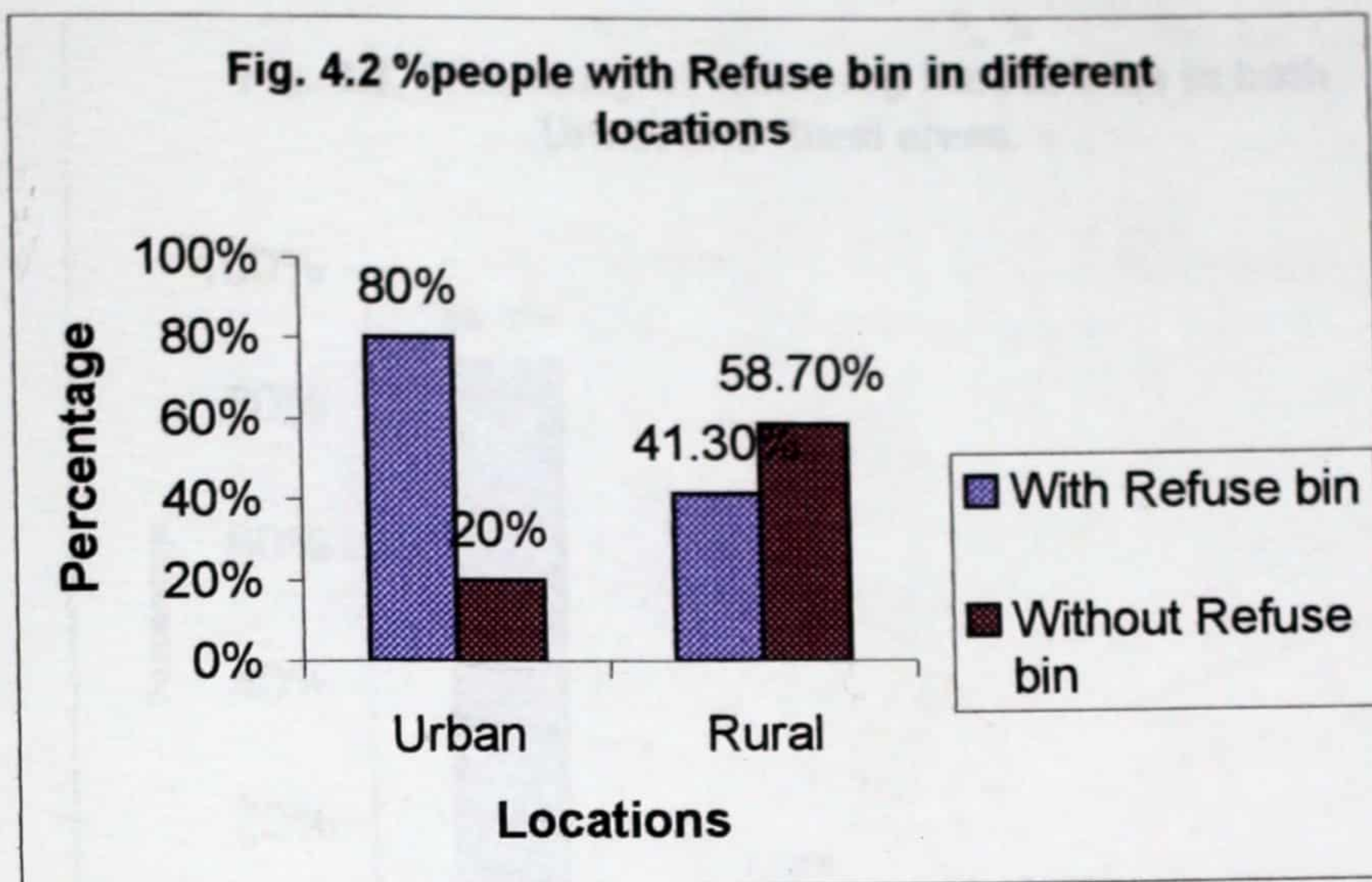
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Table 4.2: Percentage of Urban and Rural population with refuse bin.

Locations	With Refuse bin	Without Refuse bin.
Rural	41.30%	58.70%
Urban	80%	20%

Fig. 4.1 %People with Refuse bin in both rural and urban areas

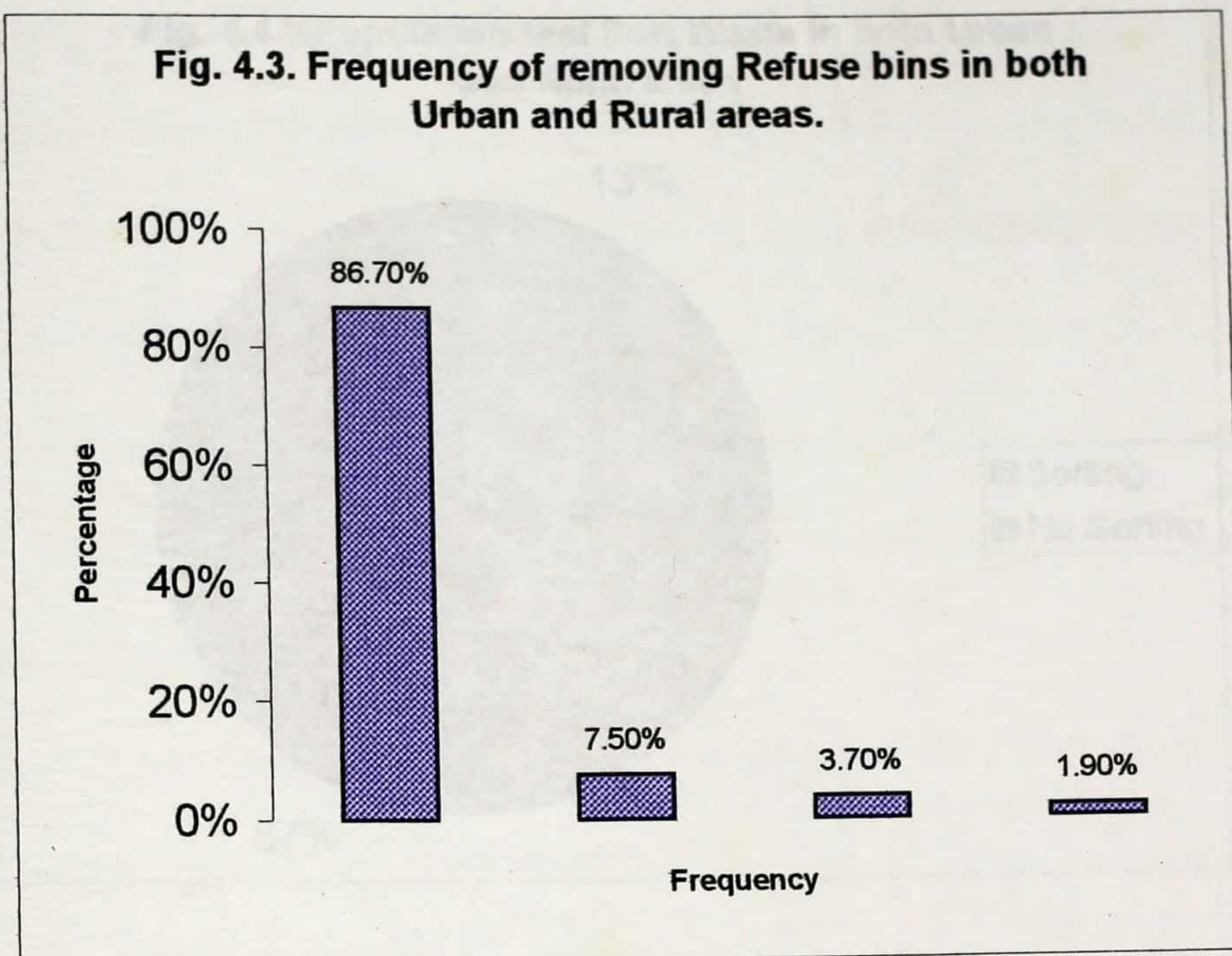




As already noted, people living at the outskirts of settlement areas dump their refuse near their vicinity. From Table 4.3, 86.7 per cent of the population having refuse bins empty them daily. This is illustrated in Fig. 4.3. This attitude is encouraging since the refuse will not stay with them to decompose to give bad odour.

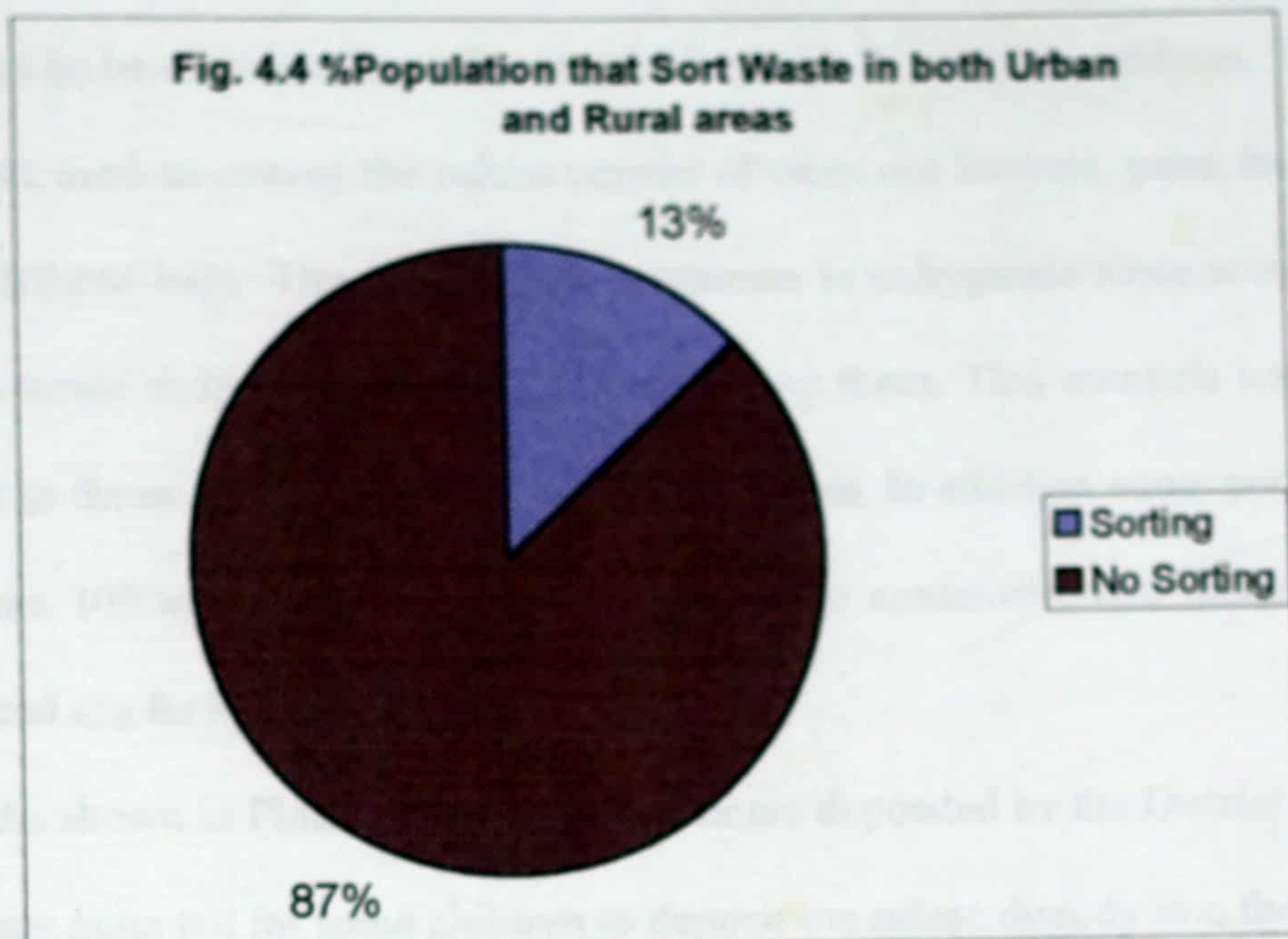
Table 4.3. Frequency of removing refuse bins in rural and urban areas.

No. of times in a week.	Percentage
Daily	86.7
Once	7.5
Twice	3.7
Thrice	1.9



Regular disposal of refuse will ensure regular flow of waste material to the site where compost will be prepared.

Domestic waste sorting is not a common practice in both rural and urban communities. As shown in Fig 4.4, only 13 per cent of the population do sort their waste whilst the remaining 87 per cent bulk everything together. People who sort their refuse do so to provide food to their domestic animals such as goats, sheep and pigs.



Waste sorting if encouraged at the point of generation will enhance composting process as well as minimize the cost of compost preparation. Adequate education on the reasons for sorting will yield positive results. As shown in Table 4.4, out of the fifteen assemblymen interviewed, 33.3 per cent strongly agreed and 53.3 per cent agreed that domestic waste would be sorted if people are educated to do that.

Table 4.4. Sorting of Domestic Waste with Education.

Agreement rating	Percentage
Strongly agree	33.3
Agree	53.3
Uncertain	6.7
Disagree	6.7
Strongly disagree	-

Refuse is conveyed in small containers by hand to storage points/refuse containers to be evacuated by refuse trucks from the Districts Assemblies. The small containers used to convey the refuse consist of worn out buckets, pans, baskets and even polythene bags. The use of these containers is unhygienic since some of their contents could drop/drip onto the people carrying them. This compels some of the children to throw the rubbish at unauthorized places. In addition some people travel more than 300 metres before getting to the refuse containers; and this distance is considered too far by some people.

As shown in Plate 2, the refuse containers deposited by the District Assembly for use are quite tall for some children to deposit the refuse directly into them. All the containers are not evacuated within a day because they are all not full. This creates an untidy situation around the containers, especially during the weekends. On the average, six (6) containers, out of twelve (12), which are deposited at various points in the municipality, are conveyed to disposal sites each day.

4.3 Equipment and Personnel needed in Composting

The process of composting could be achieved under natural conditions without necessarily using sophisticated machinery. Given favourable conditions, organic components will decompose fully within three (3) months. Bamako experience of compost making as recorded by Lardinois and Arnold, 1995 could be employed in absence of heavy equipment. Spade, brooms, pushcarts, protective clothing together with trucks which convey refuse to the disposal sites could be used in the process.

The social status of people employed in waste handling is very low. Supplementary income from the sale of compost, as well as a basic "on the job" training would motivate waste handlers to do a good and reliable job. This will in turn reduce the hazards of crude waste dumping and ultimately achieve the goals of effective solid waste management. According to the head of the waste management unit of the Ho District Assembly, three (3) workers would be sufficient to sort the amount of waste disposed each day. Additional two (2) people may be needed to turn the compost and load trucks which convey compost to farmers and other users.

4.4 Willingness and Ability and to Pay

Table 4.5 indicates the willingness of people to pay for services in waste management. About 17.3 per cent of respondents expressed their willingness to pay fully and 57.9 per cent were willing to pay partially for waste management services. However, only 36 per cent really paid something. Unfortunately, the monthly payment towards waste disposal services for households refuse could not be sustained. Many people did not continue the monthly payment after the initial one. Monthly payment for waste disposal services is virtually non-existent in the rural communities. The Ho District Assembly (HDA) introduced a monthly levy of ₵1,000.00 on each family in Ho towards the disposal of refuse

Table 4.5 Willingness to pay for Waste disposal.

Willingness	Frequency	Percentage
Pay fully	42	17.3
Partial Payment	142	57.9
No Payment	61	24.8

In addition, people who use water closet or private KVIP are expected to pay ₦40,000.00 to the District Assembly before their septic tanks are emptied by a cesspool emptier. Thirty-six per cent of the respondents paid varying amounts, ranging between ₦200.00 and ₦150,000.00 whilst a greater proportion of 64% did not pay anything. Table 4.6 illustrates the percentage of the urban population who pay some amount for waste disposal services. The modal amount paid is ₦1,000.00 and this constitutes 23.6 per cent of the people who paid. A further analysis of the people who paid revealed that 18.6 per cent paid less than ₦1,000.00, 66.1 per cent paid ₦1,000.00, and 15.3 per cent paid more than ₦1,000.00 per month towards waste disposal services (Table 4.6). Members of some household shared the amount they have to pay among themselves. A respondent who operates a public KVIP paid ₦150,000.00 for the use of a cesspool emptier. This amount is raised from the payment people made each time they visit the toilet. People pay a token amount of ₦50.00 for each visit to public KVIP (Plate 3). Other people who paid more than ₦1,000.00 use either water closet (W.C) or KVIP which necessitates the use of a cesspool emptier.

Table 4.6. Analysis of amount paid towards waste disposal

Amount Paid	Frequency	Percentage
Less than ₱1,000.00	11	18.6
₱1,000.00	39	66.1
More than ₱1,000.00	9	15.3

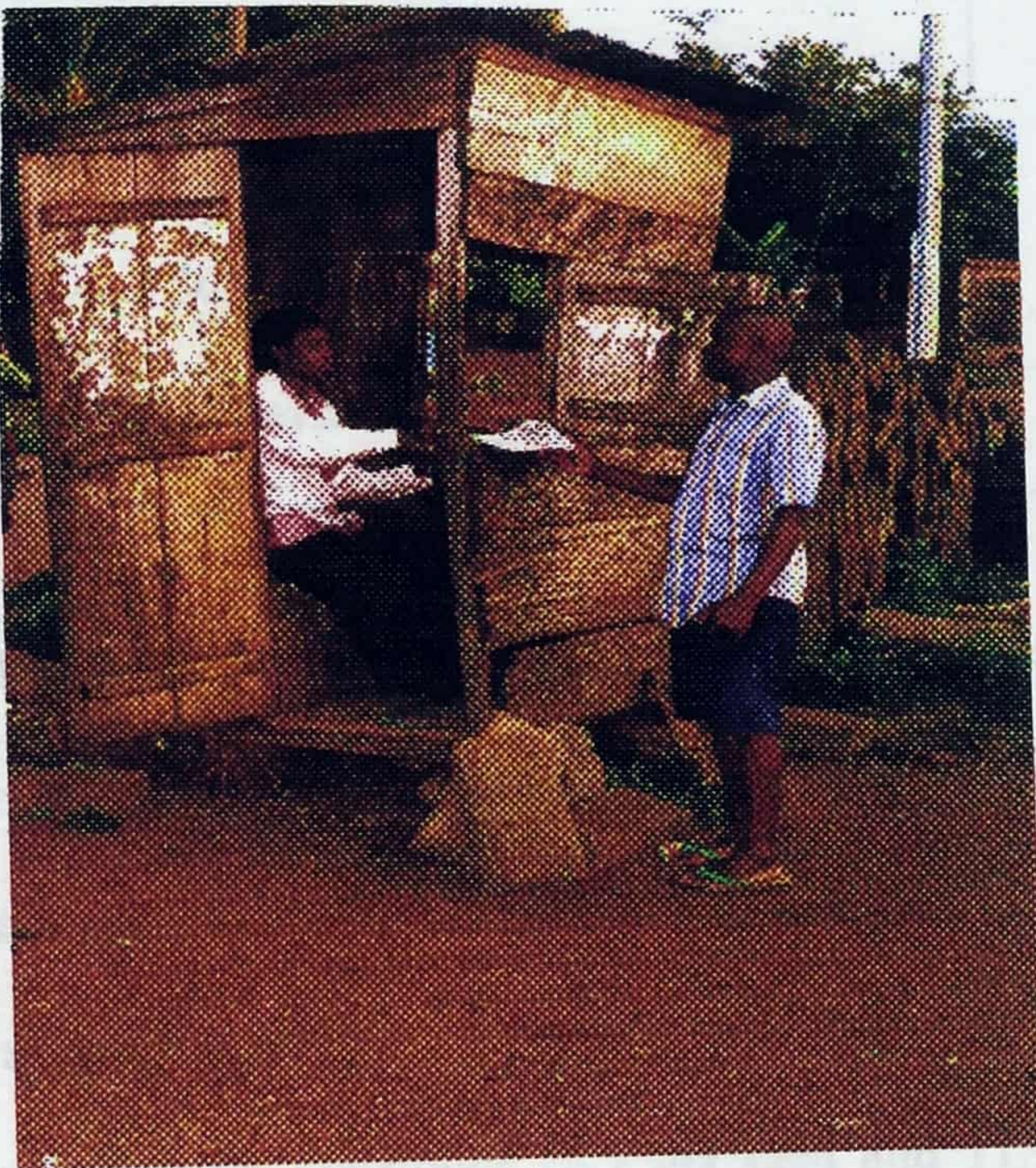


Plate 3 Payment at KVIP Kiosk

Table 4.7 Monthly contribution towards waste disposal in Ho.

Category	Amount (¢)	Frequency	Percentage
Civil/Public servants	200.00	2	1.2
Artisans	500.00	9	5.5
Farmers	1,000.00	39	23.6
Traders	3,000.00	2	1.2
Students	8,000.00	2	1.2
Others	10,000.00	2	1.2
	25,000.00	2	1.2
	150,000.00	1	0.6
	No payment	106	64.0

The disparity in actual payment to the willingness to pay expressed might be due to poor education prior to the introduction of the payment concept. Civil/Public servants constitute 57.6 per cent of the respondents who made payment towards waste disposal services. This group of people receive regular income and are well informed. Traders and farmers constitute 16.9 per cent and 11.9 percent respectively of the respondents who paid. These groups of people have fluctuating and seasonal income.

Table 4.8 Category of people, who contributed towards waste disposal services,

Category	Frequency	Percentage
Civil/Public Servants	34	57.6
Artisans	5	8.5
Farmers	7	11.9
Traders	10	16.9
Students	2	3.4
Others	1	1.7

4.5 **Introduction of compost Pits in premises.**

The assemblymen interviewed accepted compost pits to be constructed in their premises to a great extent. Table 4.9 shows 33.3 percent each of respondents who either strongly agree or just agree to the acceptance of compost in their premises. About 26.7 percent of the respondents were not sure whether people would accept the pits in their premises, and 6.7 percent disagreed completely.

Table 4.9. Acceptance of compost pits in premises

Acceptance	Frequency	Percentage
Strongly agree	5	33.3
Agree	5	33.3
Uncertain	4	26.7
Disagree	1	6.7

Compost pits, if accepted in household premises will ensure a more efficient system of waste collection. The dump sites will not be too far from the point of refuse generation. Besides, individuals will undertake waste sorting vigorously because they will not like their pits to be full in a very short time with non-degradables. Above all, other recyclable could be made available to any other consumers that might be interested in them. People who objected to it might have done so because of the odour that might be generated in the vicinity or the cost element that might be involved. Table 4.10 shows the response of assemblymen as to whether District Assemblies should partially assist individuals to build compost pits.

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Table 4.10. District Assemblies or donors should partially assist individuals to build compost pits.

Acceptance	Frequency	Percentage
Strongly agree	7	46.7
Agree	6	40.0
Disagree	1	6.7
Strongly disagree	1	6.7

From the Table 4.10, 86.7 per cent are in favour of donors assisting individuals to defray part of the cost involved in constructing compost pits while 13.4 per cent are not in favour of the idea. If individuals build compost pits in their premises, it will minimise the assembly's expenditure by more than 50 per cent since compostable materials are more than 50 per cent of domestic waste. In addition it will provide income to individual household through the sale of compost. Thus, materials, which would have, otherwise, been a total waste, would have been turned into something that is profitable. Nonetheless a project such as this will require proper layouts in the town to ease the evacuation of the compost from the pits.

4.6 Perception on Compost Use for Crops

There is high acceptance of food produced from domestic waste compost. From Table 4.11, 76.3 per cent of the entire respondents indicate that they will

consume food produced from domestic compost. There is, however, a remarkable difference in the acceptance rate among rural and urban communities. Eighty-five per cent of the rural population as against 72.7 per cent in urban areas agreed to consume food produced by using compost from domestic waste (Table 4.11). This difference might be due to adverse conviction about domestic waste because of the nuisance it creates among the urban communities.

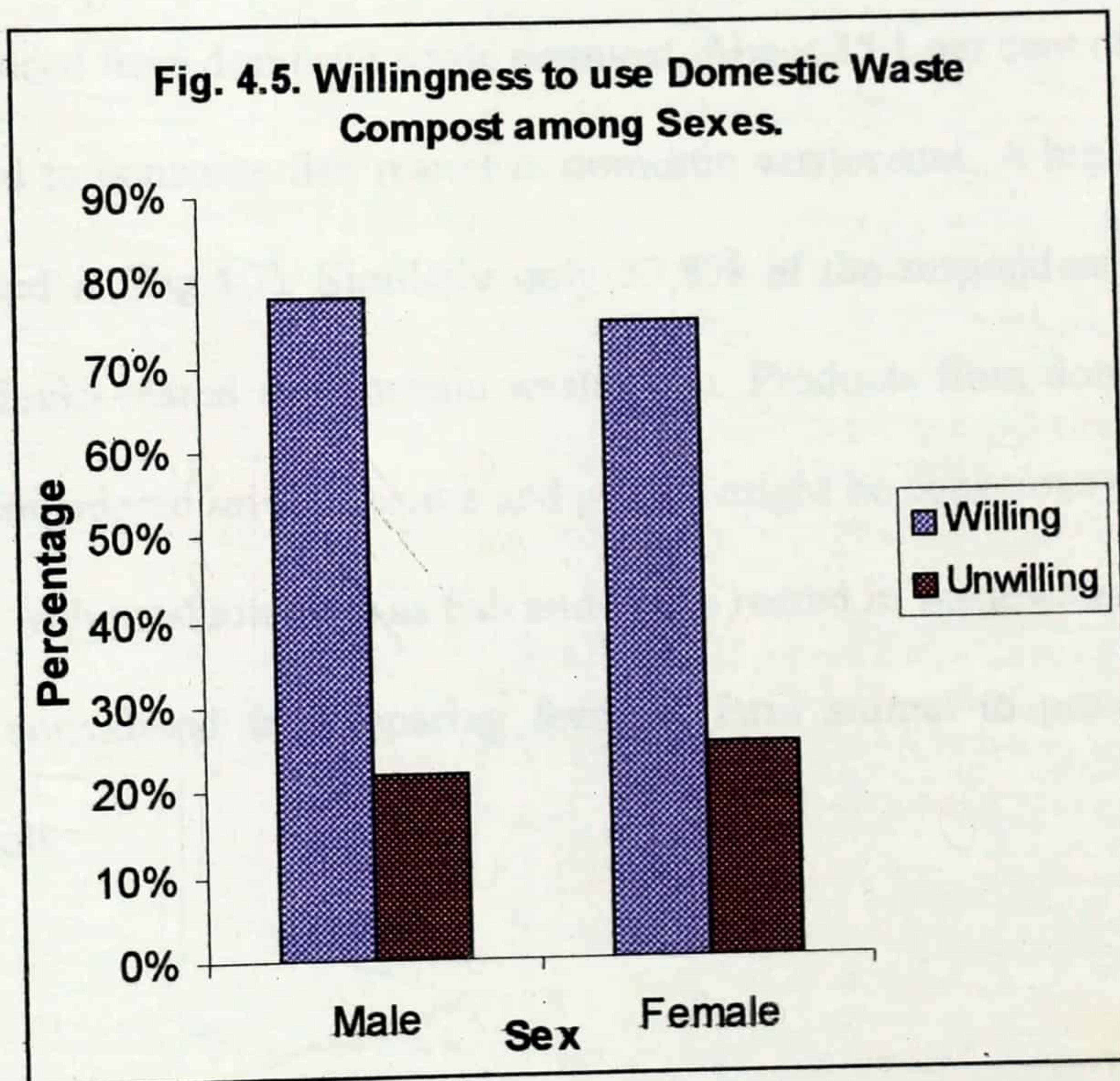
Table 4.11 Willingness to use Domestic Waste Compost

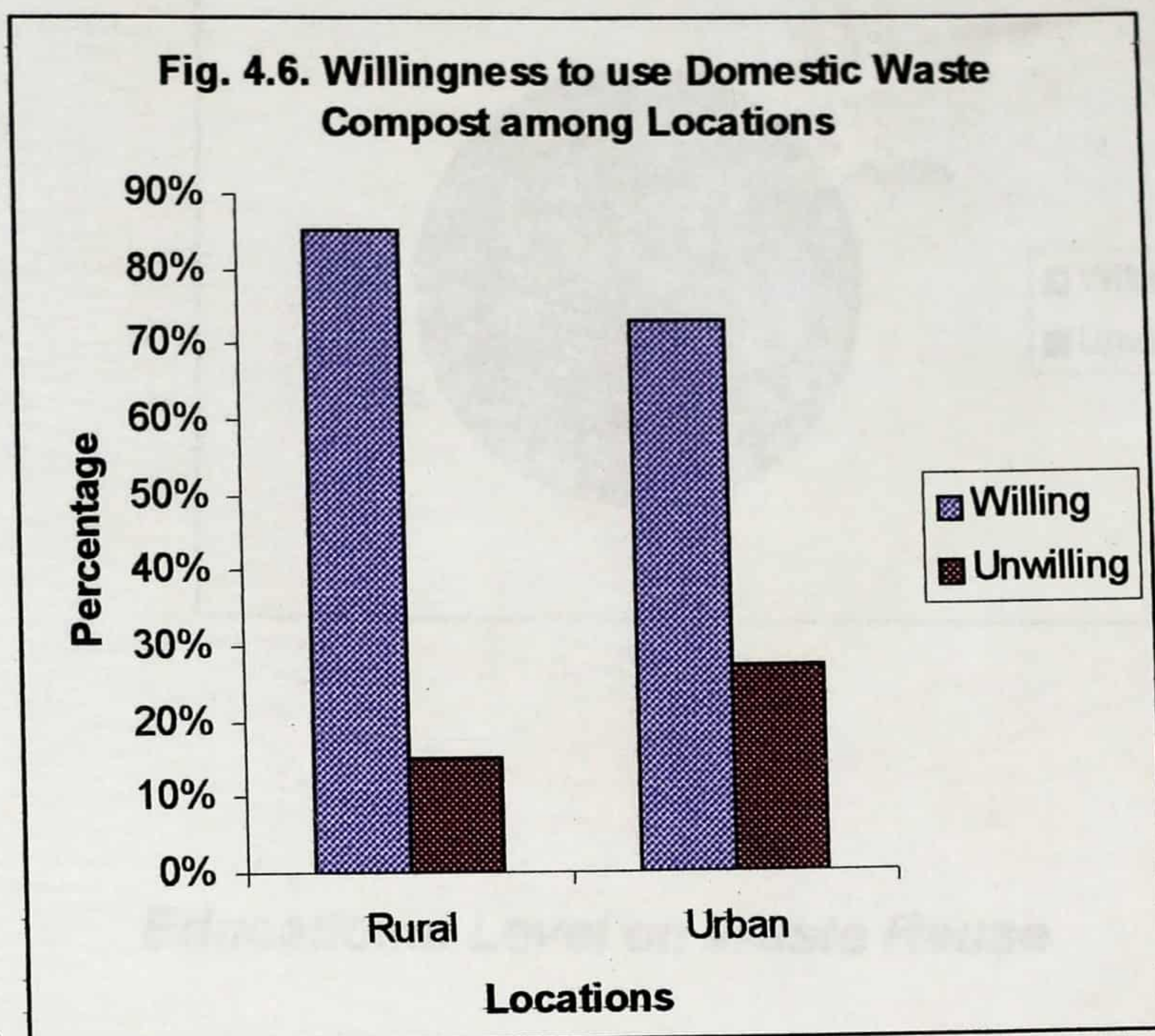
Class of People	Frequency		Percentage	
	Yes	No	Yes	No
Rural	68	12	85	15
Urban	120	45	72.7	27.3
Male	93	26	78.2	21.8
Female	95	31	75.4	24.6
Total	188	57	76.3	23.7

It is however interesting to note that gender has no great difference on the acceptance of food from domestic waste compost (Fig 4.5). About 78.2 per cent of men and 75.4 per cent of women agreed to accept food produced from domestic waste compost. Among Ghanaian culture, consumers normally do not probe the source of

the food crop they buy. Consumers might have formed their opinions but are not very skeptical when it comes to purchasing from the market.

The high degree of acceptance rate is an indication that there will be market for compost if the price and its usage competes favourably with the use of chemical fertiliser. Since, according to Caincross and Feachem (1993), compost is a good soil conditioner with high fertilizing ability, farmers could be encouraged to have preference for compost over chemical fertilizer. This calls for involvement and commitment on the part of Ministry of Food and Agriculture to educate and motivate farmers to adopt the use of compost. Initially, farmers could only be asked to pay for the transportation cost of compost to their farms. If they have fully adopted its use, the farmers themselves would be more than ready to pay for the full cost and transportation of the compost to their farms because of its immense benefits.

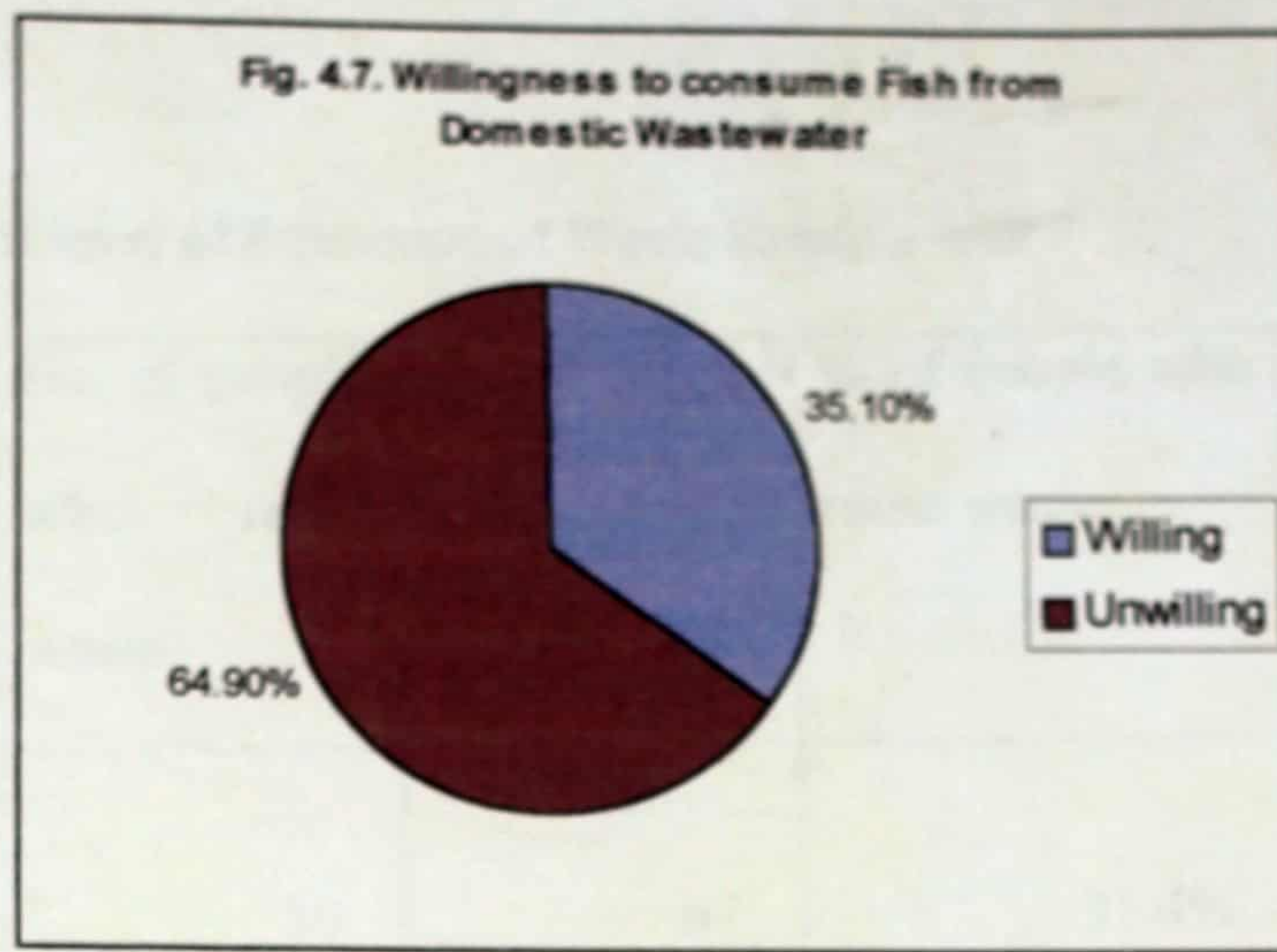




4.7

Perception on Fish Cultivated in Wastewater.

Fish produced from domestic wastewater did not receive similar patronage as crops produced from domestic waste compost. About 35.1 per cent of the respondents have agreed to consume fish reared in domestic wastewater. A higher percentage of 64.9 rejected it (Fig.4.7). Similarly only 53.8% of the respondents have agreed to consume ducks reared in domestic wastewater. Products from domestic wastewater might be considered unwholesome and people might be conscious of the health risks associated with products such as fish and ducks reared in wastewater. These products might be considered for preparing feed for farm animal to provide their protein requirements.



4.8 Educational Level on Waste Reuse

Differences existed in the effect of formal education on waste reuse. The difference is however not great. From Table 4.11, 31.4 per cent and 26.9 per cent of people educated up to Junior Secondary School (JSS) and above JSS respectively indicate that they reuse domestic waste. This result however indicates that a very large proportion of the respondents do not reuse their waste. This assertion indicates that education on waste management, if any, might be centred on environmental cleanliness. Environmental cleanliness does not put much emphasis on waste reduction, reuse, and recycling; which are key elements in waste management. In this instance, waste is "shifted" with its associated problems from one point to the other. Thus useful resources are forever lost and the over accumulation of these materials may have deleterious effect leading to pollution and loss of life.

At a confidence level of 95%, confidence interval for the rural area was 5.3, for the urban area 7.79 and 5.13 for the combined data.

Table 4.12 Effect of level of Education of Waste Reuse

Educational Level	No. of people who reuse waste.	No. of people who do not reuse	% of People who reuse waste	% of People who do not reuse waste
Up to JSS	30	67	31.4%	68.6%
Above JSS	40	108	26.9%	73.1%

4.9 Economic Evaluation

As already pointed out by Turner (1992), authorities have statutory duty to collect and dispose of municipal waste. In view of this, District Assemblies receive support either in kind or cash or both from the central government for their waste collection and disposal activities. It is thus very difficult to determine their investment cost since they are not operating purely on competitive commercial scale. At the Ho District Assembly, they have about 12 large refuse containers, a truck and a cesspool emptier vehicle, managerial staff, field staff, protective clothing, spade/shovels, brooms, rakes, etc which are used in waste collection and disposal. Table 4.13 shows the operating cost and revenue for the 1999 fiscal year. The total expenditure stands at ₵84,354,326.00 and this covers only fuel cost on waste disposing vehicles and salaries paid from the Assembly's own coffers. The daily wage is approximately ₵3,000.00 per person

Table 4.13. Operating cost and revenue from HDA on waste disposal.

Item	Expenditure (€)	Income (€)
Refuse truck	34,538,804	
Cesspool	13,815,522	
Salaries	36,000,000	
Revenue		34,019,804
Total	84,354,326	34,019,804

This excludes the salary of the management staff who draw their salaries from the Accountant General.

The entire revenue of €34,019,804 is obtained from the services of the cesspool. The services of the cesspool is demand driven and a trip is valued at €40,000.00. As earlier noted, people have to pay an amount of €50.00 for each visit at the KVIP and the agents in charge have to pay at the District Assembly before the septic reservoirs are emptied. The story is not different for individuals who own such facilities.

It could be realised, at a glance, that, even without depreciation, investments costs and maintenance costs, the Assembly is running at a great loss; €50,334,522.00 annually. Going by the Polluter Pay Principle, the District Assembly should find a means of retrieving this amount from the beneficiaries. This could be done through fees and taxes on the beneficiaries but it is difficult for the assembly to implement. There are many undeveloped building plots that are overgrown with bushes. If the

Assembly should insist on payment of fees and taxes, it might result in indiscriminate dumping; unless there is strict watchdog system or legal provision to prosecute offenders.

Another likely source of getting revenue to cushion the Assembly's expenditure on waste collection and disposal is through the production and sale of some recycled products. Compost is one of such products. It could be possible provided the investment cost does not outweigh the revenue to be obtained from it.

Composting under natural condition requires just a shed and a pavement for storing the compost. According to the Head of waste management unit of Ho District Assembly, approximately three (3) labourers are enough to sort the refuse disposed each day. As earlier on noted, on the average, six (6) containers are conveyed to disposal site each day. The volume of each container is approximately 10.93m^3 hence, about 65.58m^3 garbage is generated daily. From Table 2.1, it could be deduced that about 80 per cent of domestic waste in Ghana are compostable. Therefore 52.464m^3 of compost materials are generated daily. Again it has been noted that the bulk density of waste is higher in developing countries than in developed countries (Table 2.2). Taking a density of about 0.4kg/l (0.04kg/m^3) then 2.0986 tons of compost materials are generated daily. However compost will shrink by 20%, hence 1.68 tons of compost will be produced daily after the first barge of compost is ready. This quantity is equivalent to 613.3tons annually.

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The formula, NPV = $\sum_{t=0}^{t=T} \frac{B_t - V_{ct}}{(1+r)^t}$ could be used

to determine the economic viability of the compost production project. In this formula the symbols denote the following:

K = Capital investment

T = Project lifetime (20years)

B_t = Yearly benefits.

V_{ct} = Yearly operating cost (i.e, running cost, salaries, and depreciation,

r = discount rate (35%), and

t = anytime in the projects lifetime.

The capital investment cost will consist of the cost of clearing the project site, the building of concrete pavements, sheds, protective clothing, and tools for turning the compost. This cost is estimated to be ₦843,541,870.00 (Appendix 2).

As already noted, The Ho District Assembly incurs ₦84,354,326.00 as the total running cost of waste disposal annually. Assuming six (6) people are involved in the composting exercise (labour intensive) and if each person is paid a daily wage of ₦5,000.00, then an amount of ₦10, 800,000.00 will be spent on salaries. Thus an amount of ₦95,154,326.00 will be the total running cost (V_{ct})

Each ton of compost is valued at ₦250,000.00. If 613.2 tons of compost are produced yearly, then the annual revenue from the sale of compost will be ₦153,300,000.00.

However, the Ho District Assembly has realized ₵34,019,804.00 as revenue from waste disposal, hence the annual total revenue will be ₵187, 319,804.00 (Bt).

In the initial years of the compost project, it is obvious that the project cannot pay off its investment and running costs. The period the project will start making positive gain is after the time (t) when $NPV = 0$. In other words, the decision rule applicable to the NPV should be proceeded with as it demonstrates a greater "earning" power than the course of action, which is to invest in the alternate investment "opportunity" expressed through the discount rate. In financial terms, this might best be compared to the bank deposit rate of interest (Cusworth and Franks, 1993).

Taking the bank discount rate of 35%, the NPV will be zero after 7.38 years (Appendix 3). Thus, the project will start making real gains in the 8th year. Theoretically therefore, composting could be viewed as a financially viable project notwithstanding the environmental benefits.

4.10 *Agricultural Benefits*

The usefulness of compost as a soil conditioner and a fertilizer cannot be over-emphasised. As already noted by Ghana/CIDA Grains Development Project (1987), to supply 50kg N/ha to maize, one needs to apply 5tons/ha of good quality compost. Thus, for a hectare field of maize a farmer may require either 5tonnes of compost or about 6.6 bags of NPK 15-15-15 fertilizer (Table 4.13).

Table 4.13 Comparative cost of using Compost and NPK 15-15-15 on a hectare of land.

Fertilizer	Quantity/ha	Unit Price (¢)	Total Amount (¢)
Compost	5tons	50,000.00	1,250,000.00
NPK, 15-15-15	7 bags	80,000.00	560,000.00

From the above table, it could be deduced that, using compost for maize cultivation on a hectare of land is more expensive than using N.P.K. 15-15-15. The expenditure of using compost on a hectare of land exceeds that of N.P.K. 15-15-15 by ¢690000.00. It is worth noting, however that compost has beneficial residual effect on the soil. With continuous cropping, the amount of compost that need to be applied to the soil would reduce with time.

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CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS.

Domestic waste management poses a great threat to District/Municipal Assemblies. The practice of waste Reduction, Reuse and Recycle (3R) is totally absent in the operations of Ho District Assembly. The practice by which many people send their refuse to designated storage containers daily is quite high and encouraging. People need to be educated on waste reduction, reuse and sorting. The current situation whereby waste from various household are collected and disposed off on dumping grounds (waste shifting) gives rise to loss of valuable resources. Besides, the practice is environmentally unfriendly.

The culture of "Polluter Pays" as far as refuse /garbage generation is concerned is non-existent among people. Thorough education is needed and reliable collection mechanism need to be evolved. People are however not hesitant to pay ₵500.00 for each visit they make to the public toilet. They are also more than willing to pay for the services of cesspool emptier whenever septic tanks are to be emptied.

People have expressed their willingness to consume food produced from domestic waste compost but to a lesser extent for fish reared in domestic wastewater.

It is also possible for individuals to construct compost pits in their premises if they are given financial material support.

REFERENCES

The cost of waste collection and disposal is very expensive. Currently, Ho District Assembly spends more than ₦80m. in waste disposal activities. Compost preparation apparently, is a viable venture to recoup some of the expenses made on waste collection and disposal.

It may cost the Ho District Assembly an amount of about ₦843,541,870.00 as capital investment over a period of twenty (20) years and an annual running cost of about ₦95,154,326.00 to undertake a compost project. This projection could produce 613.2 tons of compost valued at ₦153,300,000.00 annually.

Furthermore, composting will create job for many categories of workers. This will also help save foreign exchange earnings and promote a sound environment.

It is worth noting, however, that because of the odour, flies and health hazards that might be associated with domestic waste composting, the venture might not be attractive to a greater proportion of people/investors.

It is recommended that further studies should be carried out on the effect of income level and extent of education on waste management practices.

REFERENCES

- Agyeiwa, G. (Unpublished). Pilot study of domestic Waste Disposal – Sorting at the source of generation, KNUST, Kumasi.
- Allen, G. H and Hephew (1976). Recycling of waste through aquaculture and constraints to wider applications. FAO Technical Conference. Aquaculture. Japan.
- Amoah E. K. (1996). WATSAN News Vol. 3. No. 1
- Baily, R (1996). Water and Environmental Management in Developing Countries. London pp 89-451.
- Bringer, R. P (1992). Waste management by prevention. Treatment and Handling of waste. Chapman and Hall, London. Pp 27-40.
- Buckman, M and Lindhquist T (1992). The nature of waste problem; a question of prevention. Treatment and handling of Waste. Chapman and Hall. London Pp 27-40.
- Caincross, S and Feachem R. G. (1993). Environmental Health Engineering in the Tropics, 2nd ed. John Wiley & Son Ltd. pp11-213.
- CTA; Spore, No. 49. Feb. 1994.
- Cusworth, J. W. and Franks, T. R. (eds) (1993). Managing projects in Developing Countries, Longman Group. U.K. pp139-141.
- Edon- D – Enger and Bradly S. (1995). Environmental Science, A study of relationship. McGraw-Hill companies Inc. pp361-371.
- Edwards. P. (1980) A review of recycling organic wastes with emphasis on the tropics, Aquaculture, Japan.

- Feachem, R. G. Bradly, D. J. Garlick, H. and Mara. D. D. (1983). Sanitation and Disease – Health aspect of Excreta and Wastewater management. John Wiley & Sons Ltd.. Chichester.
- Gersham. T. (1986). Small-scale municipal solid waste recovery systems. New York.
- Ghana/CIDA Grains Development Project Maize and cowpea production guide for Ghana. January 1987.
- Ghana EPA. (1995). Environmental Education Strategy for Ghana. Accra-Ghana.
- Ghana Population Census Report. (1960). Special Report on Localities by Local Authorities. Vol. II
- Hall, J. E. (1992). Treatment and use of sewage sludge. Treatment and Handling of Waste. Chapman and Hall. London. pp63-69.
- Internet (<http://www.svys.com/calculator.html#terminology>)
- Jain, A. P. and Pant, G. B. (1994). Solid waste management in India. Affordable Water Supply and Sanitation, WEDC. U. K. pp92-97.
- Kobieh, F. (1997). WATSAN News. Vol. 3, NO. 1.
- Lampkin, N(1994). Organic Farming; Farming Press. Ipswich, U.K.
- Lardinois, I. And Van der Kludert, A. (1994). Small-scale urban organic waste recovery. Affordable waste supply and sanitation. WEDC. U. K. pp101-105
- McGarry. M. G. and Stainforth. J. (1978). Compost. Fertilizer and biogas production from Human and Farm Wastes in the People's Republic of China. IDRC.
- McKee, N. (1994). Synergism in a Three-Pronged Strategy. Waterfront, March, 1994.
- N'dow F (1996) Our Cities, Our Planet. Vol. 8. No. 1.
- Pickford, J. (1995). Low-cost sanitation. A survey of practical experience. WEDC. U. K. pp24-107.

Polprasert. C. (1996). Organic Waste Recycling. 2nd ed.: John Wiley and Sons Ltd..

Chichester. Pp1-379.

Roger, P. and Roland . S (1996). Non- Governmental Refuse Collection in Low-income Urban Areas. SANDEC Report No. 1/96

Salvato, Joseph A. (1982). Environmental engineering and sanitation. John Wiley & Sons, Inc.

Selvan, P. (1994). Community based SWM project preparation. Affordable waste supply and sanitation, WEDC, U.K. pp108-110.

WHO (1989). Health Guidelines for the use of Wastewater in Agriculture and Acquaculture, WHO Technical Report Series No. 778 (Geneva. World Health Organisation).

Wanyeki, L. M. (1996). Urban waste. The Urban context; Supplement to Our Planet. Vol. 8.

Wolfenschn, J. D. (1996). Crucibles for development. Our Planet. Vol. 8. No.1

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APPENDIX I: QUESTIONNAIRES ON WASTE MANAGEMENT

PUBLIC PERCEPTION ON FOOD AND ENERGY FROM DOMESTIC WASTE

1. SEX: M F
2. AGE GROUP: 20-29 30-39 40-49 50+
3. LOCATION:
4. OCCUPATION:
5. Have you ever attended School? Yes No
6. What was the highest level of school attended?
 Primary J.S.S. S.S.S. Other (Specify) _____
7. Can you read a letter or newspaper easily, with difficulty, or not at all?
 Easily With difficulty Not at all
8. Do you usually listen to a radio at least once a week? Yes No
9. Do you view a television at least once a week? Yes No
10. Do you have a refuse collection bin in your house? Yes No
11. Is the waste separated or sorted into different bins? Yes No
12. How often is your refuse bin emptied? Daily Once a week
 Twice a week Thrice a week Others (specify) _____
13. What kind of toilet facility do your household have? Water closet
 Pan Pit KVIP Others (specify) _____
14. Which organisation is responsible for the management of domestic waste in your locality?
 District/Municipal Assembly Private Others (specify) _____
15. Are you satisfied fully, partially or not at all with the level of service offered by (15) above?
 Fully satisfied Partially satisfied Not satisfied

16. Have you ever had any education of information on safe methods of waste disposal?
 Yes No
17. Have you ever sold any waste material from your house? Yes No
18. If Yes, name some of the items sold.
19. Have you ever had any information or education on waste utilization? Yes No
20. Do you re-use any part of your household refuse? Yes No
21. Will you feel comfortable using treated waste water for domestic purposes such as washing and flushing of toilet? Yes No
22. Will you like to use waste water to irrigate your crops? Yes No
23. Will you consume fish and ducks reared in waste water? Yes No
24. Will you like to apply compost prepared from domestic waste and night soil on your crops? Yes No
- ? 25. Do you have anything against biogas as source of energy for cooking food?
 Yes No
26. Is waste disposal a problem in your locality? Yes No
27. From which of the following ways do you receive information about waste management?
 Radio TV Newspapers Mobile vans
 Sanitary/Health workers Others (specify)
28. Is the information received in 28 detailed enough to urge you manage your domestic waste? Yes No
29. Have you ever been consulted as an individual or as a group on the best way to dispose of your domestic waste? Yes No
30. Is education/information on waste management very effective in your locality?
 Very effective Moderately effective Not effective
31. How would you rate the method of communication on waste management?
 Excellent Very good Satisfactory Poor

32. How much do you pay on waste disposal in a month?

33. Will you accept a technology which would help you re-use night soil?

Yes

No

34. Will you be ready to pay fully, partially, or not at all for the technology in 33?

Fully

Partially

Not at all

APPENDIX 2

CONSTRUCTION OF COCRETE FLOOR SIZE – 77mmx38.5mx0.23m

ITEM	DESCRIPTION	QTY.	UNIT	RATE (¢)	AMOUNT(¢)
A	Clearing of Site – 100mx50m	-	-	-	3,500,000
B	<u>Setting Out</u>				
1	25mmx30mmx4.30m wawa boards	70	No	18,000	1,260,000
2	50mmx100mmx4.30m wawa scantling	40	No	12,000	480,000
3	100mm Nails	1	Box	115,000	115,000
4	75mm Nails	1	Box	115,000	115,000
5	66mm Nails	1	Box	115,000	115,000
6	Solignum	45	Liters	1,200	54,000
7	Turpentine	27	Liters	1,800	48,600
8	100mm paint brush	3	No	11,000	33,000
9	Labour men working for two days	-	-	20,000	200,000
					<u>2,420,000</u>
C	Excavation (Excavator)	-	-	-	2,000,000
D	<u>Formwork</u>				
1	25mmx30mmx4.30m wawa boards Reuse the setting out boards	-	-	-	-
2	Provision is made for nails in the setting-out	-	-	-	-
3	Labour – 5 men working for two days	-	-	20,000	200,000.00

ITEM	DESCRIPTION	QTY.	UNIIT	RATE (¢)	AMOUNT (¢)
E	<u>Concrete work 1:3:6 mix</u>				
1	Cement	2730	Bags	27,000	73,710,000
2	Sand	55	Trips	80,000	4,400,000
3	3" Stone	110	Trips	200,000	22,000,000
4	3" Iron Rod for Mat	2826	Length	15,000	42,390,000
5	Allow for water	-	-	-	1,200,000
6	Allow 35% for labour	-	-	-	<u>50,295,000</u>
					¢193,995,000
	SUMMARY				
A	Cleaning of Site	-	-	-	3,500,000
B	Setting-out	-	-	-	2,420,000
C	Excavation	-	-	-	2,000,000
D	Formwork	-	-	-	200,000
E	Concrete Work	-	-	-	<u>193,995,000</u>
					202,115,000
F	Add 20% for Contingencies	-	-	-	<u>40,123,000</u>
					<u>242,238,000</u>
	No of concrete floor required		2		<u>484,476,000</u>

Shed Construction : Size – 200mx50m

ITEM	DESCRIPTION	QTY.	UNIT	RATE (¢)	AMOUNT ¢
1	10cmx10cmx4.8m wooden	36	No	30,000	1,080,000
2	post				
3	Metal Shoe	34	No	50,000	1,700,000
4	5cmx10cmx4.8m Scantling	700	No	17,000	11,900,000
5	Solignum	100	litres	1,000	100,000
6	Turpentine	50	litres	1,600	80,000
7	15cm paint brush	4	No -	11,000	44,000
8	Roofing Sheets (1.2mx2.4m)	25	Pkts	1,050,000	26,250,000
9	15cm wire nails	3	boxes	115,000	345,000
10	10cm wire nails	4	boxes	115,000	460,000
11	7.5cm wire nails	2	boxes	115,000	330,000
12	Roofing nails	30	pkts	23,500	705,000
13	Felt	20	metres	2,500	<u>50,000</u>
					42,239,000
14	Allow 35% for labour	-	-	-	<u>14,783,650</u>
					57,022,000
15	Add 20% for Contingencies	-	-	-	<u>11,404,000</u>
					68,4237,180
16	Add concrete Floor		-	-	<u>81,869,7555</u>
					150,296,935
17	Estimate for 2 sheds				<u>300,597,870</u>

APPENDIX 3. CALCULATION FOR THE TIME (t) WHEN NPV = 0.

$$NPV = \sum_{t=0}^{t=T} K + \frac{(Bt - Vct)}{(1+r)^t}$$

$$NPV = K + \frac{(Bt - Vct)}{(1+r)^t}$$

i. e. $0 = K + \frac{(Bt - Vct)}{(1+r)^t}$

$$-K = \frac{Bt - Vct}{(1+r)^t}$$

$$(1+r)^t = \frac{-Bt + Vct}{K}$$

$$t \log(1+r) = \frac{-Bt + Vct}{K}$$

$$t = \frac{\log(-Bt + Vct) / K}{\log(1+r)}$$

But $Bt = 187,319,804.00.$ (Annual revenue).

$Vct = 95,154,326.00.$ (Annual running cost).

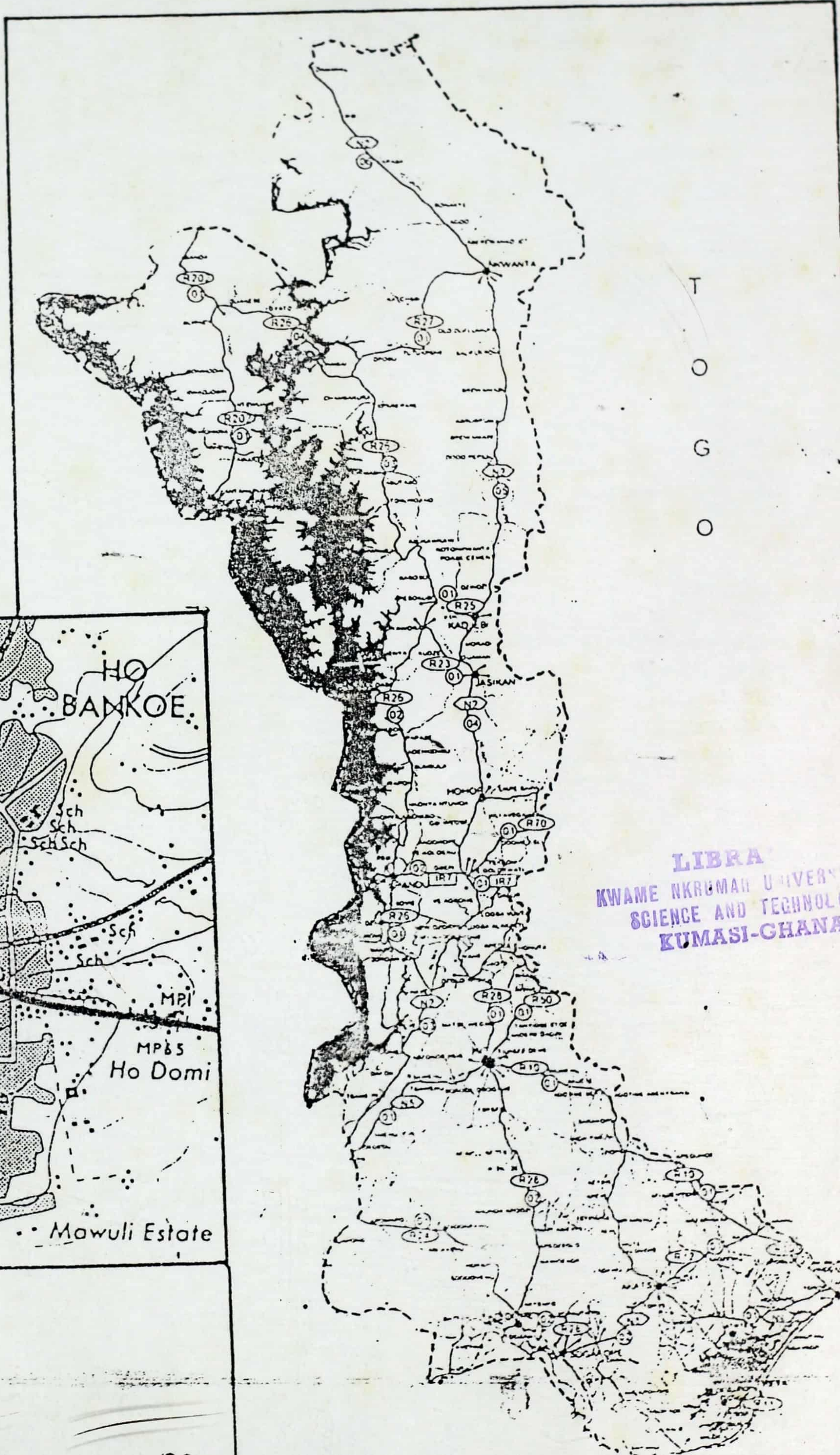
$K = 843,541,870.00.$ (Capital investment)

$r = 35\%.$ (Discount rate).

Hence, $t = 7.38.$

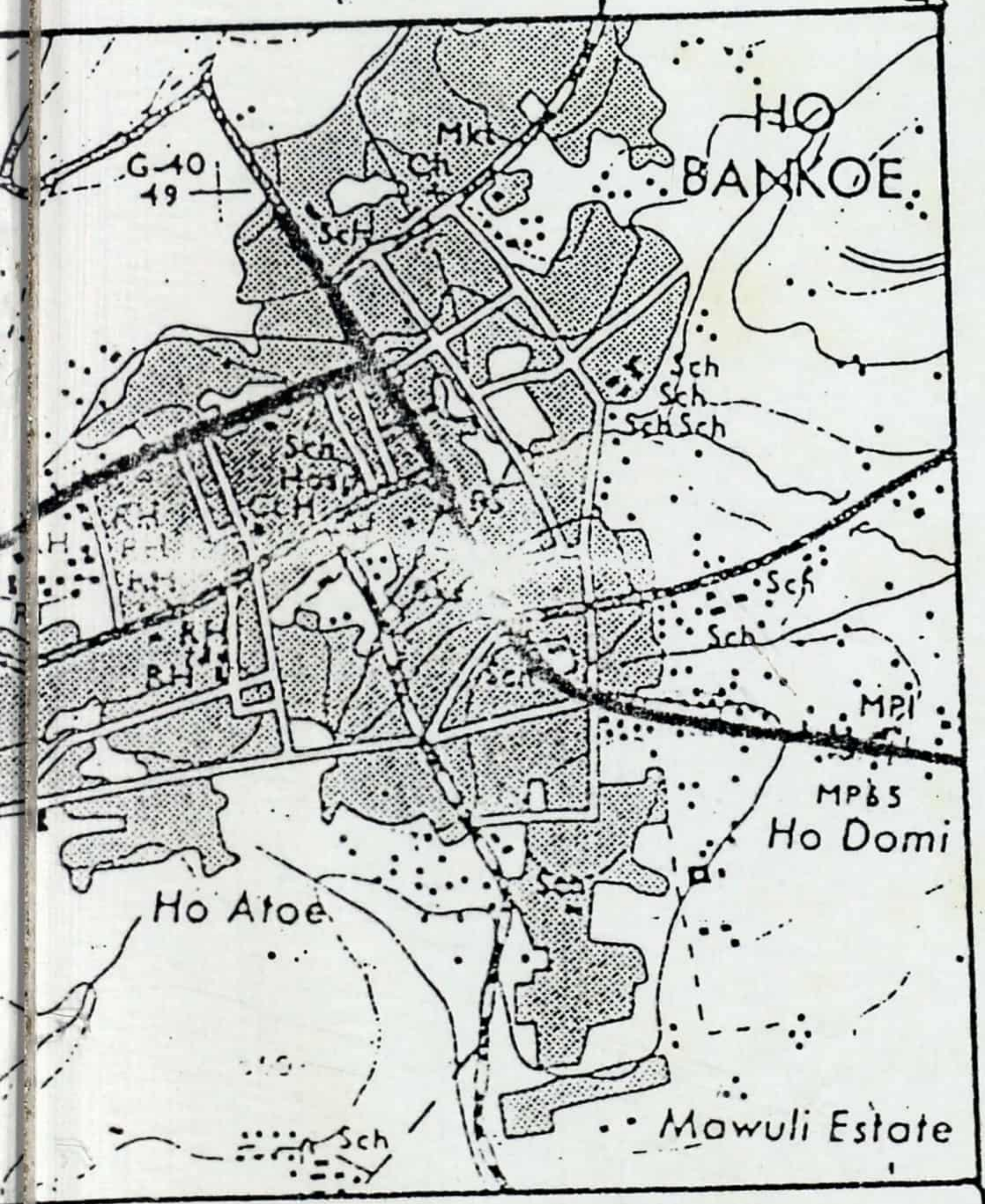
LOCATION MAP

Volta Region



T
O
G
O

Ho Town



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