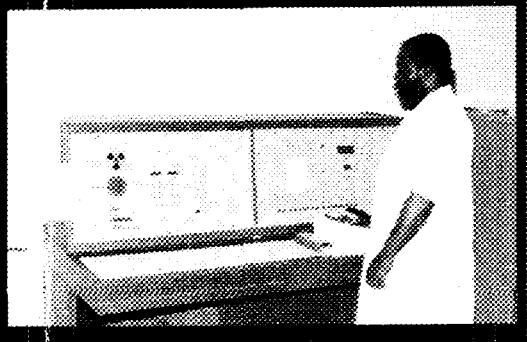

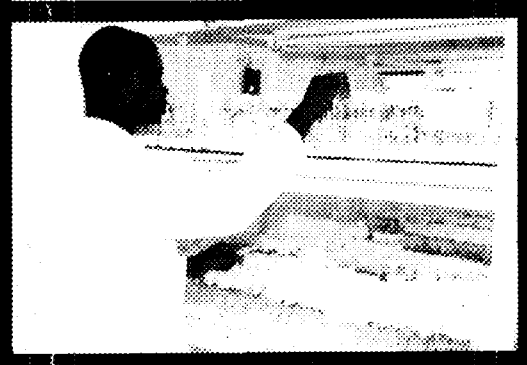

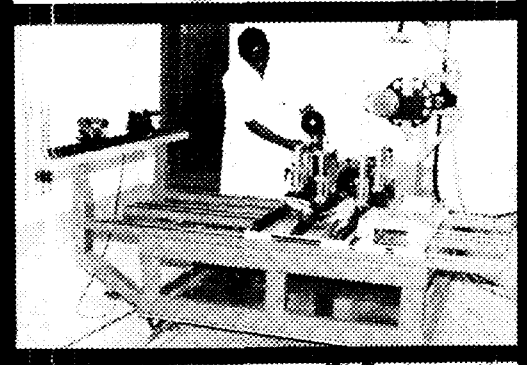

GHANA ATOMIC ENERGY COMMISSION

GHANA ATOMIC ENERGY COMMISSION

Annual Report

2001

GHANA ATOMIC ENERGY COMMISSION

ANNUAL REPORT 2001

PREPARED BY THE DOCUMENTATION & PUBLICATION COMMITTEE

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PREFACE

The Structure and the Mission of the Ghana Atomic Energy Commission are defined in Act 204 of 1963 and re-defined by the PNDC Law 303, 1993 and Atomic Energy Commission Act 588 of 2000. These enjoin the Commission to conduct as well as promote research and development into peaceful uses of atomic energy through the application of nuclear and radioisotope techniques and modern biotechnology aimed at enhancing agricultural productivity to ensure food security, effecting improvement in human and livestock health and industrial development as well as ensuring environmental protection.

This report covers activities, programs and operations of the Commission in 2001 in fulfillment of the statutory responsibility as embodied in the Act.

The Ghana Atomic Energy Commission wishes to thank the Ministry of Environment Science (MES), the Ministry of Food and Agriculture, the Ministry of Finance, the Controller and Accountant General, Agencies and Departments, CSIR, the Universities, AFRA, and the I.A.E.A as well as the Private Sector for their kind co-operation during the year under review. GAEC hopes to rely on their continuous support in the years ahead.

EXECUTIVE SUMMARY: ANNUAL REPORT 2001

INTRODUCTION

The Act 204 of 1963, which established the Ghana Atomic Energy Commission (GAEC), and now superseded by Act 588 of 2000 enjoins it to assume the sole responsibility in Ghana for all matters relating to the peaceful uses of atomic energy.
This Executive Summary highlights the activities of the Ghana Atomic Energy Commission in the area of nuclear science and technology for the sustainable development of Ghana.

The functions of the Commission among others are:

(a) To advise the Government on questions relating to nuclear energy, science and technology.

(b) To engage in research and development activities, as well as in the publication and dissemination of research findings and other useful technical information.

(c) To establish, for the purposes of research and in furtherance of its functions, Institutes of the Commission and to exercise control over the boards of management of the Institutes.

Currently there are three main operational Institutes of the GAEC namely:

- The National Nuclear Research Institute (NNRI)
- The Radiation Protection Board (RPB)
- The Biotechnology and Nuclear Agriculture Institute (BNARI)

In addition the Commission has a Secretariat, which is responsible for the day-to-day management of the Commission.

Two specialised Centres, the National Centre for Mathematical Sciences (NCMS) and National Radioactive Waste Management Centre (NRWMC) are also placed under the Secretariat for administrative purposes.

SUMMARY OF ACTIVITIES

A brief summary of the activities as well as achievements of the Institutes and the Centres of the Commission for the year 2001 is as follows:

1.0 NATIONAL NUCLEAR RESEARCH INSTITUTE (NNRI)

The NNRI has three departments: Physics, Chemistry and Nuclear Engineering and Material Science and two Centres, the Radiation Technology Centre and the Digital Electronics and Nuclear Instrumentation Centre.

MAJOR RESEARCH FACILITIES AT THE NNRI

The major research facilities are located at the following Laboratories and Centres:

(i) Ghana Research Reactor, GHARR-1 Centre
(ii) Radioisotope-based Technology Unit at GHARR-1 Centre.
(iii) Non- Destructive Testing (NDT) Laboratory
(iv) X-ray Fluorescence Spectroscopy Laboratory
(v) Neutron Activation Analysis Facility at GHARR-1 Centre
(vi) Solid State Nuclear Tract Detection (SSNTD) laboratory

(vii) Radiotherapy and Nuclear Medicine Centre at Korle Bu
(viii) Radiation Technology Centre
(ix) Nuclear Instrumentation and Electronics Facilities at DENIC
(x) Mechanical Workshop

The main research activities and services include:

- Elemental analysis of geological materials and biological samples;
- Non-destructive testing of joints;
- Gamma irradiation leading to radiation processing of foods and
- Non-food items samples, design, production and maintenance of electronic parts, devices and equipment;
- Diagnosis and treatment of cancer by radiotherapy;
- The use of Co-60 and Cs-137 for scanning of columns of petroleum refinery; and
- The use of Am-Be neutron source for determination of liquid levels of hydrogenous materials.

These facilities and equipment of the Institute are also used for manpower training of students from our universities and African researchers through the International Atomic Energy Agency's sponsored regular training programmes

2.0 RADIATION PROTECTION BOARD (RPB)

For the year 2001, the major activities were:

i. Occupational Radiological Exposure in the Mining Industry.

ii. Studies on the Terrestrial Gamma Radiation in and around the Metropolitan area of Accra..

iii. Studies on the optimisation of patient dose in Radiation Therapy.

iv. Under Food Contamination certification, 212 samples were issued with certificates.

The RPB continued to offer services to the public and the private sectors of the economy in the following areas;

- Food and Environmental Monitoring
- Personnel Monitoring
- Dosimetry

3.0 BIOTECHNOLOGY AND NUCLEAR AGRICULTURE RESEARCH INSTITUTE (BNARI)

The Institute has three main departments where research and developmental programmes are carried out: Department of Plant and Soil Science, Department of Food Science and Radiation Processing and Department of Animal Science.

3.1 MAJOR RESEARCH FACILITIES

The following are the main facilities used by scientists to carry out research during the year:

i). Entomology Laboratory/Tsetse Insectary.

ii). Food Science Laboratory

iii). Microbiology Laboratory

iv). Plant Tissue Culture Laboratory.

v). Stored Products Laboratory.

vi). Ten-hectare arable land for field research

3.2 RESEARCH AND DEVELOPMENT

The Institute was involved in the following Research and Development programmes, among others:

(i) Agronomy and Crop Improvement using Biotechnology and related techniques.

(ii) Food Science and Nutrition Programme.

(iii) Radiation Processing Programme.

(iv) Food and Environmental Biotechnology Programme.

(v) Entomology Programme.

(vi) Animal Nutrition Programme

(vii) Animal Reproduction and Health Programme

4.0 NATIONAL RADIOACTIVE WASTE MANAGEMENT CENTRE (NRWMC)

The Centre continued to offer services to companies that generate radioactive materials in the country on their waste management. The centre received 4 Sr-90 sealed radiation sources from the British-American Tobacco Company (Ghana) for management as part of commercialisation drive

5.0 NATIONAL CENTRE FOR MATHEMATICAL SCIENCES

The National Centre for Mathematical Sciences (NCMS) continued its programmes of training by organising Regional and Inter-regional Courses in Mathematical and Physical Sciences

5.0 CONCLUSION

This report covers the activities of GAEC for the year 2001. It also seeks to inform policy makers, industries, the business community and the general public about the immense contribution GAEC is making through the peaceful application of nuclear energy in Agriculture, Health, Environment and Industry.

MEMBERS OF THE COMMISSION

Prof. D. Adzei-Bekoe	Chairman
Prof. A. Ayensu	Member
Prof (Mrs) Aba Andam	Member
Prof. S. Yeboah Mensah	Member
Prof. J. H Amuasi	Member
Prof. J.E Ephraim	Member
Dr. Rexford Osei	Member

MEMBERS OF THE EXECUTIVE COMMITTEE

During the year under review, the Executive Committee of the Commission was made up of the following members:

1.	Director General	Prof. J.H. Amuasi	Chairman
2.	Deputy Director General	Prof. E.K. Osae	Member
3.	Director of NNRI	Prof. A.W.K. Kyere	Member
4.	Director of RPB	Prof. C. Schandorf	Member
5.	Director of BNARI	Prof. G.Y.P. Klu	Member
6.	Director of Finance	Mr. E.V. Asare	Member
7.	Ag. Dir. of Administration	Mr. C.K. Duodu	Member
8.	Head of Chemistry Department	Prof. J.H. Ephraim	Member
9.	Ag. Head of Internal Audit	Mr. D.P. Amevor	Member
10.	Head, Dept of Food Science & Radiation Processing	Prof. (Mrs.) V. Appiah	Member

REPORT OF THE DIRECTOR GENERAL

INTRODUCTION

Once again the Good Lord has brought us to the end of another working year, a year in which we have been both witnesses of and participants in the changes that are taking place in the country as well as the world outside.

We have seen in this country the smooth transfer of power from one government to another through the ballot box. We have heard the clarion call of positive change and its response - zero tolerance for corruption.

We at the Ghana Atomic Energy Commission have seen the inauguration into office of a new seven member Governing Board by His Excellency, the President of the country on the 23rd November 2001.

At the inauguration, the President, Mr. J.A. Kuffour, urged us to justify the billions of cedis of the taxpayers' money being spent on us annually. We are being asked to increase productivity and make our presence felt in the industrial development of the country.

This report, like the previous years', brings with it stock taking and sober reflection on our achievements and failures in the course of the year. Such stocktaking is necessary to enable us take account of our strengths and shortcomings with a view to fashioning out appropriate strategies to address any lapses in the course of the year.

R & D AND COMMERCIALISATION

We have operated under a very tight budget throughout the year. Research funds have not been released to enable us fully carry out our research activities.

We continue to rely heavily on the International Atomic Energy Agency (IAEA) support for most of our research activities. In spite of this constraint, the IAEA Research Contracts in the Institutes are on-going.

With the promulgation of the Atomic Energy Commission Act, 2000 (Act 588) by the Parliament, the stage is set for full-scale commercialization of our research activities. The drive towards commercialization must be intensified on all fronts. The Commission needs to move away from the dependence solely on Government for funding for its activities. The key to realizing this dream and becoming self-supporting is to focus greater attention on the commercialization drive. We must also redouble our efforts in our research work and increase public awareness of our activities in order to dispel the wrong notion in some circles that the Commission is not making any impact in the socio-economic development of the country. I challenge the Directors of the Institutes and indeed all and sundry to project the activities of the Commission through both the print and electronic media.

I am pleased to mention that the Management of GAEC has, during the year under review, prepared a National Public Relations Plan covering the period 2002-2006 as a

strategy to promote nuclear-based technology in Ghanaian Economy. More importantly, it is to increase public awareness of the benefits of nuclear science and technology and thereby improving the image of the Commission.

With respect to Internet connectivity for GAEC effort was made in September to get the Commission linked to the University of Ghana's Internet Server via radio link.

In conclusion, let me once again remind us about His Excellency, the President's philosophy of positive change and zero tolerance for corruption. Our individual attitude to work will collectively make a positive or negative impact on the level of Science and Technology in this country. It is my hope that we shall all resolve to improve upon our performance in the coming year. The judicious use of our limited resources will ensure maximum results and the realization of our goals and objectives. The Commission has a duty and responsibility to spearhead the technological advancement of this country in Agriculture, Industry, Health and Environmental Protection. I have no doubt that you will individually and collectively rise up to the challenge.

I very much appreciate the tremendous support of the Executive Committee members. With their concerted effort the Commission has been able to function without a Board for the first three quarters of the year. We gladly welcome the members of our newly inaugurated Governing Board, especially the Chairman, Professor D. A. Bekoe. The Commission stands to benefit tremendously from his strong scientific background and several years rich experience as Vice-Chancellor of the University of Ghana. He had previously served as a Board member of the Commission in the late sixties.

We give thanks to God Almighty for His sustaining grace throughout the year. It is my prayer that the Good Lord will guide and direct our ways in the coming year to His great glory.

J.H. AMUASI
DIRECTOR GENERAL

SECTION ONE

1.0 GHANA ATOMIC ENERGY COMMISSION

1.1 INTRODUCTION

The Ghana Atomic Energy Commission (GAEC) was established by an act of Parliament, Act 204 of 1963 to be the sole Authority in Ghana responsible for matters relating to the peaceful uses of atomic energy. The Act 203 has been superseded by Act 588 of 2000 to make provision for GAEC to engage in biotechnology and other related technologies and also to promote the commercialisation of research and development results through its Institutes.

1.2 FUNCTIONS OF THE COMMISSION

The functions of the Commission prescribed by the new Act 588 are:

(a) To make proposals to the Government for Legislation in the field of nuclear radiation and radioactive waste management.

(b) To advise the Government on questions relating to nuclear energy, science and technology.

(c) To establish, for the purpose of research and in furtherance of its functions, Institutes of the Commission and to exercise control over the boards of management of the Institutes.

(d) To encourage and promote the commercialisation of research and development results through its Institutes.

(e) To supervise the carrying out of all requirements designed to secure the safety and health of radiation workers and the environment.

(f) To engage in research and development activities, as well as in the publication and dissemination of research findings and other useful technical information.

(g) To oversee and facilitate the development of human resources in the fields of nuclear science and technology, and to promote the training of scientific, technical and non-scientific personnel of the Commission.

(h) To maintain relations with the International Atomic Energy Agency and other similar international and national organisations on matters of research and development of nuclear energy and nuclear technology.

(i) To collaborate with Universities and Research Institutes for the purpose of conducting research into matters connected with the peaceful uses of nuclear energy and technology.

1.3 VISION, MISSION AND OBJECTIVES OF GAEC

1.3.1 VISION

The Ghana Atomic Energy Commission is committed to become the leading organization that creates national prosperity through research and development and effective utilization of nuclear science and

technology, biotechnology and other related technologies.

1.3.2 MISSION

1. To promote research and development through the application of nuclear and biotechnology techniques in order to:

   - Enhance agricultural productivity and food security;
   - Improve human health and safety;
   - Enhance Industrial development.
   - Ensure human and environmental protection from the harmful effects of ionizing radiation;

2. To advise Government and create national awareness of the potential of nuclear energy as a viable source of electrical energy worth introducing into Ghana's energy mix for enhancing her energy security and sustainable development.

3. To create an environment which enables GAEC to commercialise its research outputs.

1.3.4 AIMS AND OBJECTIVES

1. To advise the government on matters relating to nuclear energy, science and technology;

2. To make proposals to the Government for legislation in the field of nuclear radiation and radioactive waste management;

3. To encourage and promote the commercialisation of research and development outputs;

4. To supervise all activities designed to secure safety and health of radiation workers and the environment;

5. To engage in research and development activities as well as publications and dissemination of research findings and other useful technical information;

6. To facilitate the development of human resources in the fields of nuclear science and technology and biotechnology;

7. To maintain relations with the International Atomic Energy Agency (IAEA) and other similar international and national organizations on matters of research and development of nuclear energy, nuclear and nuclear related technologies as well as biotechnology;

8. To collaborate with the Universities and other Research Institutions for the purpose of promoting the peaceful uses of nuclear energy and biotechnology;

9. To develop the capacity to manufacture nuclear instruments and equipment;

10. To perform any other functions related to the peaceful uses of atomic energy as determined by the Government.

1.4 CURRENT ORGANISATIONAL STRUCTURE OF GAEC

The present organisational structure is made up of the Commission otherwise known as the GAEC Board, the Secretariat and the Research Institutes namely:

- The National Nuclear Research Institute (NNRI)

- The Radiation Protection Board (RPB)
- The Biotechnology and Nuclear Agriculture Research Institute (BNARI)

1.4.1 THE COMMISSION (GAEC BOARD)

The Ghana Atomic Energy Commission headed by a Chairman is the Governing Body responsible for policy formulation and strategic direction of the Commission. The seven-member Board was appointed by the Government in November 2001

1.4.2 SECRETARIAT

The Secretariat is responsible for the day-to-day management of the Commission

The Executive Secretary is the Chief Executive Officer of GAEC. He reports to the seven-member Commission.

The Acting Director of Administration supports the Executive Secretary in the administration of all common services and physical facilities of the GAEC.

The Deputy Executive Secretary is responsible for all Scientific and Technical matters of the Commission including the matters concerning senior members of the Commission.
The Executive Committee headed by the Executive Secretary is the body that oversees the implementation of decisions and policies made by the GAEC Board.

1.4.3 INSTITUTES

The three (3) Institutes of the Commission namely, NNRI, RPB and the BNARI carry out the Research and Development activities. Each of the institutes is headed by a Director.. The Institutes are semi-autonomous. Each Institute also has a Management Board which reports to the Commission.

SECTION TWO

2.0 GAEC SECRETARIAT

2.1 FUNCTIONS OF THE CENTRAL ADMINISTRATION

The Secretariat is the nerve center of the organization responsible for the overall co-ordination of policy and general management of research and support services. The key support service functions within the Secretariat include the Central Administration, Finance and Accounting and Internal Audit. For financial and budgetary purposes, the National Centre for Mathematical Sciences (NCMS) and the National Radioactive Management Centre (NRWMC) have been placed under the Secretariat.

The principal function of the Central Administration is to provide high quality service in the following functional areas: Human Resource Management (HRM); Facilities Management including Estate, Clinic and School: Library and Information Services; General services including Sanitary, Security, Horticulture, Electrical, Transport, Postal Service; and General Administration.

The main objective of the Central Administration is to effectively administer the HRM policies and programs as well as allied support services in order to assist the Commission to attract, develop, utilize, motivate and retain the right calibre of personnel to perform its functions effectively and efficiently.

The department implemented several action plans and programs in the areas of human resource management, office administration, facility and asset management, staff training and development and provision of logistics and equipments to enhance operational effectiveness. Consequently, the Human Resource policies and procedures were put together in a manual as an institutional document to serve as reference document for action.

2.2 PERSONNEL

2.2.1 APPOINTMENTS

Mr. David Huledu - Senior Accounts Clerk, Finance Department.
Dr. (Mrs) E. Kufe - Medical Officer (on secondment)
Mr. D. D. Asare - Accountant, Finance Department
4. Mr. C. G. Arhin - Accountant, Finance Department.
Mr. W. A. Osei Mensah - Accountant, Finance Department
Mr. Isaac Lartey - Teacher, Education.
Ms Selina Bluie - Teacher, Education.
Mr. Stephen Baidoo - Senior Accounts Clerk, Finance Department.

2.2.2 RETIREMENTS

Mr. S. Adjei - Senior Security Officer.

2.2.3 RESIGNATION

Ms. Agnes Ofosu Boamah - Nurse.

2.3 REVIEW OF SECTIONAL PROGRAMS UNDER THE SECRETARIAT

2.3.1 NATIONAL RADIOACTIVE WASTE MANAGEMENT CENTRE (NRWMC)

The NRWMC continued with its program of assisting generators of radioactive materials in Ghana to manage their waste. In this regard, the Centre received four Sr-90 sealed radiation sources from the British-American Tobacco Company for management as part of the GAEC's commercialisation drive. Waste was collected from selected dump sites in the country and analysed using Neutron Activation Analysis.

Facilities of the Centre were made available to students from the Physics Department of the University of Cape Coast who undertook their project work.

Under its AFRA RAF/4/015 project, the Centre received from the International Atomic Energy Agency, a contamination monitor, a gamma spectrometer and an alpha, beta-gamma survey meter. The equipment greatly enhanced the activities of the Centre in the area of identification of old spent sources.

The NRWMC is faced with many challenges. Serious efforts have to be made in advancing the radioactive waste management program in Ghana. Full implementation of the waste management regime in the country will need commitment and support from the Government of Ghana.

2.3.2 NATIONAL CENTRE FOR MATHEMATICAL SCIENCES (NCMS)

The National Centre for Mathematical Sciences (NCMS) was established to provide research, training and education in mathematical sciences for the staff of the Ghana Atomic Energy Commission (GAEC) and young Mathematicians, Scientists and Engineers from Africa. Work at the Centre was dominated by two major activities namely continuation of its Ph. D program in Mathematical Sciences and hosting of the following workshops:

(i) 4th Regional College on Mathematical Modelling, Simulation and Optimization, 8 – 18 May, 2001.

(ii) 7th Edward A. Bouchet Regional College on Functional Analysis and its Applications to Differential Equations, 9 – 21 July, 2001.

(iii) 4th Regional College on the Teaching of Physics at the Secondary School Level, 24 July – 3 August, 2001.

(iv) 3rd Regional College on the Teaching of Mathematics at the Secondary School Level, 7 – 17 August, 2001.

(v) Regional College on Frontiers of Condense Matter Physics, 20 – 24 August, 2001.

2.3.3 DEPARTMENT OF HEALTH SERVICES (GAEC CLINIC)

A total of 19,529 patients were seen at the *Out Patients Department in the year 2001* compared to 14,572 in the previous year, an increase of 34 %. Of this number, 13, 825 (70.8%) were paying patients and 5,704 (23.5%) were staff and their dependents. Those registered for the first time totaled 4, 594 patients.

2.3.4 LIBRARY

The mission of the Library is to provide access to relevant scientific and technical information to support the research and development activities of the Institutes and

Centres under the Commission. The objectives of the library during the reporting year included expanding access to library and electronic resources, strengthening its infrastructure and ensuring that staff members are provided with appropriate skills for improved job performance.

The total stock stood at 4251 monographs and 170 journal titles. Fifty-five (55) books were acquired. Thirty (30) items were added to the International Nuclear Information System (INIS) Database as Ghana's input to the system. The Library offered the following services: photocopies were provided to meet internal and external requests; 300 items were lent to users; assisted users perform CD-ROM/On-line literature searches, and hosted 6 Diploma Students from the Department of Information Studies who undertook their practical fieldwork.

2.3.5 GAEC PRIMARY SCHOOL

The population of the School increased from 480 in 2000 to 500 pupils in 2001. Pupils of the school are enrolled from within and outside the Commission with 50% of the children being wards of the Commission's staff. The School continues to maintain its high academic standard.

2.3.6 ELECTRICALS SECTION

With staff strength of six, the Section was able to carry out the following maintenance work at the Reactor site and the residential area:-

- The broken down underground cable of the NNRI block was replaced.
- The BNARI's Accounts office was wired. The service lines feeding Flat B were replaced.
- The standby generator was rewound and its supply cable to the circuit breaker bus bar was replaced.
- Power was restored to the Mathematics Centre, the RPI and the NDT Laboratory.

The Section also constructed an overhead line of about 600m away from the substation to feed the BNARI's new building. The latter would have cost the Commission several millions of cedis if the work had been done a private contractor.

2.3.7 WORKS & MAINTENANCE SECTION

Work focused on access road repairs as well as maintenance and repairs of residential accommodation. The section also undertook repair work at GAEC offices. No major project was tackled owing to lack of funds.

2.3.8 SECURITY SECTION

With a staff strength of 57, the Security Section continued with its functions of protecting and safeguarding the assets of the Commission as well as GAEC Primary School successfully maintaining law and order at the residential area and offices.

2.3.9 POSTAL AGENCY

Postal services were offered to the Commission and surrounding areas.

2.4 HUMAN RESOURCE DEVELOPMENT

2.4.1 TRAINING COURSES

Ms. Juliet Donkor, Headteacher of the GAEC Preparatory School completed a 2-year Masters Degree course in Public Administration at the University of Ghana.
Mr. W. A. Yeboah, Senior Administrative Officer, successfully completed a 2-year

Masters Degree course in Public Administration at the University of Ghana.

Mr. Eric T. Glover of the NWMRC participated in the AFRA Regional Training Course on "Management of Disused Sealed Radioactive Sources", Pretoria, South Africa, 9 - 13 July, 2001.

2.4.2 MEETINGS

Mr. Eric Glover participated in the 3rd AFRA Coordination Meeting held in Rabat, Morocco, 19 – 23 February, 2001.

Ms. Elizabeth A. Agyeman, Librarian, participated in the 29th Consultative Meeting of INIS Liaison Officers held in Vienna, Austria from 2 - 4 May, 2001.

Mr. C. Wotorchie, Senior Library Assistant, participated in a one day Seminar on Inter Library Lending Procedures and Networking of Research Libraries held at the INSTI, CSIR, Accra, Ghana, 12 July, 2001.

The First Coordinating Meeting of the Regional Project on "Sustainable Energy Development in Sub-Saharan Africa" (RAF/0/016) was held at the GAEC, Accra, Ghana, 26 - 30 March, 2001.

2.5 CONFERENCE PAPERS

Glover, E. T. and Fletcher, J. J. "Sealed Radium Sources Conditioning Operation in Ghana". Proceedings of the 27th International Waste Management Conference on High Level Wastes, Low Level Wastes, Mixed Wastes and Environmental Restoration. Organized by WM Symposia Inc., Tucson, USA. February 25 – March 1, 2001.

SUMMARY OF RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31ST DECEMBER 2001 (IN CEDIS)

ITEM CLASSIFICATION	G.A.E.C TOTAL	G.A.E.C SECRETARIAT	G.A.E.C N.N.R.I	G.A.E.C B.N.A.R.I	G.A.E.C R.P.B
RECEIPTS	¢	¢	¢	¢	¢
Government Subventions:					
Item 1	**6,368,566,267.63**	**3,057,251,174.00**	**1,757,313,395.91**	**1,080,328,226.23**	**493,673,471.49**
Item 2	539,946,699.00	**339,737,567.00**	101,536,157.00	55,638,117.00	43,034,858.00
Item 3	634,178,342.45	**634,178,342.45**	-	-	-
Item 4	-		-	-	-
Other Income	58,907,605.21	-	**26,833,144.21**	-	**32,074,461.00**
		-			
Sub – Total	**7,621,598,914.29**	**4,031,167,083.45**	**1,885,682,697.12**	**1,135,966,343.23**	**568,782,790.49**
PAYMENT					
PERSONAL EMOLUMENS (ITEM 1)					
Established Posts	2,977,999,070.73	1,655,203,958.46	702,065,840.83	435,543,956.02	185,185,315.42
Daily Rates					
SSF	289,925,949.39	146,273,169.51	87,300,651.57	53,789,998.29	2,562,130.02
	-	-	-	-	-
		-	-	-	-
	-	-	-	-	-
Other Allowance	3,100,641,247.51	1,255,774,046.03	967,946,903.51	590,994,271.92	285,926,026.05
Sub – Total	6,368,566,267.63	3,057,251,174.00	1,757,313,395.91	1,080,328,226.23	473,673,471.49

ADMINISTRATION (ITEM 2)					-
				-	-
Electricity	206,743,833.00	206,743,833.00	-		
Water	22,603,974.00	22,503,974.00	-	100,000.00	
TeleCommunications	26,105,617.42	13,872,112.42	9,808,505.00	2,425,000.00	-
Postal Charges	5,256,917.00	1,560,750.00	1,100,000.00	1,476,767.00	1,119,400.00
Office Cleaning	3,240,683.00	2,421,250.00	300,000.00	213,333.00	306,100.00
Office Consumables	65,009,084.00	7,919,362.00	41,722,389.00	11,684,000.00	3,683,333.00
Printing - Publications	5,771,627.00	2,310,950.00	100,000.00	694,205.00	2,666,472.00
Rent	690,000.00	-	200,000.00	406,667.00	83,333.00
Maintenance	29,920,385.25	17,702,344.25	7,751,376.00	699,999.00	3,766,666.00
Travel & Transport	100,870,396.00	50,609,529.00	26,803,210.00	12,251,119.00	11,206,538.00
Financial Charges					
Other Allowances	30,746,304.33	7,029,738.33	13,565,677.00	5,067,873.00	5,083,016.00
	42,987,878.00	7,063,724.00	185,000.00	0,619,154.00	15,120,000.00
Sub – Total	**539,946,699.00**	**339,737,567.00**	**101,536,157.00**	**55,638,117.00**	**43,034,858.00**
OBJECTIVE 1 SERVICE					
Uniforms/Protective Clothing	-	-	-	-	-
Teaching/Learning Materials		-	-	-	-
Material/Consumables	3,955,000	3,955,000.00	-	-	-
Printing/Publications	-	-	-	-	-
Travel/Transport	-	-			
Consultancies	15,320,000	15,320,000.00			
Sub – Total	**19,275,000**	**19,275,000.00**	-	-	-

ITEM CLASSIFICATION	TOTAL	G.A.E.C SECRETARIAT	G.A.E.C N.N.R.I	G.A.E.C B.N.A.R.I	G.A.E.C R.P.B
OBJECTIVE 2	¢	¢	¢	¢	¢
SERVICE		-			
Stationery		-	-	-	-
Training/Conference Costs	13,125,000.00	13,125,000.00	-	-	-
Materials/ Consumable	-	-	-	-	-
Printing/Publications	-	-	-	-	-
Travels/transport	-				
Sub – Total	**13,125,000.00**	**13,125,000.00**	**-**	**-**	**-**
INVESTMENT		-	-	-	-
Plant, equipment, Furniture and Vehicle					
Sub – Total		-	-	-	-
OBJECTIVE 3					
SERVICE					
Stationery		-	-	-	-
Training/Conference Costs		-	-	-	-
Materials/Consumable		-	-	-	-
Printing/Publications		-	-	-	-
Travels/Transport		-	-	-	-
Sub – Total		-	-	-	-
INVESTMENT					
Contractors Fees		-	-	-	-
Construction		-	-	-	-
Plant, Equipment & Furniture & Vehicles		-	-	-	-
Sub – Total		-	-	-	-
OBJECTIVE 4					
SERVICE					
Training Materials	600,000	600,000.00	-	-	-
Materials/Consumable	-		-	-	-
Printing/Publications	-	-	-	-	-
Travels/Transport	-	-	-	-	-
Sub – Total	**600,000**	**600,000.00**	**-**	**-**	**-**

INVESTMENTS					
Plant, Equipment, Furniture & Vehicles	-	-	-	-	-
Sub-Total	-	-	-	-	-
OBJECTIVE 5					
SERVICE					
Training/Conference Costs	-	-	-	-	-
Materials/consumable	-	-	-	-	-
Printing/Publications	-	-	-	-	-
Consultancies	-	-	-	-	-
Travels/Transport	-	-	-	-	-
Sub – Total	-	-	-	-	-

ITEM CLASSIFICATION	TOTAL	G.A.E.C SECRETARIAT	G.A.E.C N.N.R.I	G.A.E.C B.N.A.R.I	G.A.E.C R.P.B
OBJECTIVE 6					
SERVICE					
External Consultant Fees	-	-	-	-	-
I.A.E.A. General Conference	470,824,691.45	470,824,691.45	-	-	-
Foreign Travel Costs	130,353,651.00	130,353,651.00	-	-	-
Training/Conference Costs	-	-	-	-	-
Materials/consumable	-	-	-	-	-
Printing/Publications	-	-	-	-	-
Consultancies	-	-	-	-	-
Travels/Transport	-	-	-	-	-
Rent of Plant Equipment	-	-	-	-	-
Sub – Total	**601,178,342.45**	**601,178,342.45**			

OBJECTIVE 7					
SERVICE					
Materials/ Consumables		-	-	-	
Printing/Publica-tions	-	-	-	-	-
Travels/Transport	-	-	-	-	-
Sub – Total	-	-	-	-	-
		SUMMARY	**OF**	**PAYMENTS**	
ITEM CLASSIFICA-TION	**G.A.E.C TOTAL**	**GAEC SECRETARIAT**	**G.A.E.C N.N.R.I**	**G.A.E.C B.N.A.R.I**	**G.A.E.C R.P.B**
Personal emolument	6,368,566,267.63	3057,251,174.00	1,757,313,395.	1,080,328,226.23	473,673,471.49
Administration	539,946,699.00	339,737,567.00	91	55,638,117.00	43,034,858.00
Services	634,178,342.45	634,178,342.45		-	-
Investments	-	-	101,536,157.00	-	-
			-		
			-		
Grand Total	**7,601,598,914.29**	**4,031,167,083.45**	**1,885,682,697.12**	**1,135,966,343.23**	**516,708,329.49**

2.6 LIST OF PERSONNEL - GAEC SECRETARIAT

2.6.1 SENIOR MEMBERS

NO.	NAME OF OFFICER	POSITION	QUALIFICATION	DEP/SECTION
1.	Prof. J. H. Amuasi	Exec. Secretary	BSc. (Hons.) Physics, MSc. (Radiation Physics) PhD. Medical Physics	ADMINISTRATION
2.	Prof. E. K. Osae	Dep. Exec Secretary	BSc. (Hons.) Physics, MSc. Applied Nuclear Physics PhD. Nuclear Physics	ADMINISTRATION
3.	Mr. E. V. Asare	Director of Finance	C.A.	FINANCE
4.	Mr. C. K. Duodo	Ag. Director of Admisnistration	BA (Hons) Geo/Pol. Sc.), MPA	ADMINISTRATION
5.	Mr. D. L. Nerquaye-Tetteh	Prin. Adm. Officer	BSc. (Gen.), BSc. (Hons) . Dip. (Pub. Adm.)	ADMINISTRATION
6.	Mr. W. A. Yeboah	Snr. Adm. Officer	BA (Hons) Sociology with Archeology, Post Grad. Dip. Pub. Adm, MPA	ADMINISTRATION
7.	Mr. N. A. Y. Asamany	Snr. Adm. Officer	BA (Hons) Econs, Post Grad. Dip. (Public Adm.), B.L.	ADMINISTRATION
8.	Nana Ekua Sangmuah	Adm. Officer	BA Sec, Dip. Educ. , ICSA II, Post Grad. Cert. (Public Adm), Post Grad. Dip. (Pub. Adm, MPA	ADMINISTRATION
9.	Ms. Elizabeth A. Agyeman	Librarian	BA (Hons) Social Sc., Grad. Dip. (Library Studies)	ADMINISTRATION
10	Mr. A.Y. Twum-Danso	Accountant	ACCA (Inter.), AIA (Inter.)	FINANCE
11.	Mr. Eric Tetteh Glover	Scientific Officer	BSc., MSc	NRWMC
12.	Rev. Dr. Maxwell Aryee	Resident Med. Officer	B. Medicine (MB), B. Surgery (CHB)	CLINIC
13.	Ms. Juliet C. Donkor	Head-Teacher	BA (Maths), MPA	SCHOOL
14.	Mrs. Beatrice Nkyerkyer	Snr. Pharmacist	B. Pharmacy (Hons)	CLINIC
15.	Mrs. Ruth Adu Poku	Assist. Headteacher	BA, Dip. Education	SCHOOL
16.	Mr. Daniel Darko Asare	Accountant	ICA (GH) P.I	FINANCE
17.	Mr. Charles Gabriel Arhin	Accountant	B.Com, ICA (GH) Level 1	FINANCE
18.	Mr. W. O. Osei Mensah	Accountant	ICA (GH) Level 1, BA (Hons) Econs. & Law	FINANCE
19.	Mr. Emmanuel Asare	Assist. Accountant	BSc. (Accounting)	FINANCE
20	Mr. Michael Twum Danso	Assist. Sci. Officer	B.Sc. (Accounting)	NCMS

2.6.2 SENIOR STAFF

NO.	NAME OF OFFICER	POSITION	DEPT./SECTION
1.	Ms. Grace Stella Barnes	Snr. Adm. Officer	ADMINISTRATION
2.	Mr. S. N. Asante	Adm. Assistant	ADMINISTRATION
3.	Mr. E. O. Larbi	Adm. Assistant	ADMINISTRATION
4.	Mr. Violet Odametey	Technician	ADMINISTRATION
5.	Mr. C. Wotorchie	Snr. Library Assistant	LIBRARY
6.	Mr. D. Y. Evans	Snr. Library Assistant	LIBRARY
7.	Mr. J. J. K. Ocloo	Accounting Assistant	FINANCE
8.	Mr. Yakubu Labil	Accounting Assistant	FINANCE
9.	Mr. S. K. Martey	Accounting Assistant	FINANCE
10	Mr. J. K. Abruquah	Accounting Assistant	FINANCE
11.	Mrs. H. N. Badoo	Stores Officer	FINANCE
12.	Mr. K. N. Asiedu	Accounting Assistant	FINANCE
13.	Mr. J. T. Quaynor	Accounting Assistant	FINANCE
14.	Mr. J. K. Saforo	Accounting Assistant	FINANCE
15.	Mr. M. A. Torkutsah	Accounting Assistant	FINANCE
16.	Ms. Phydeliah Nodzievor	Adm. Assistant	FINANCE
17.	Mr. P. D. Amevor	Snr. Auditing Assistant	AUDIT
18.	Mr. William Kwamladza	Snr. Auditing Assistant	AUDIT
19.	Mr. Peter K. Ofosuhene	Auditing Assistant	AUDIT
20	Mr. George Asante Appiah	Auditing Assistant	AUDIT
21.	Mr. Nana Yaw Kwarteng	Auditing Assistant	AUDIT
22.	Mr. Isaac Bampoe	Stores Officer	FINANCE
23.	Mr. E. D. Atiase	Stores Officer	FINANCE
24.	Mr. Cletus Samilor	Stores Officer	FINANCE
25.	Mr. Isaac O. Asare	Principal Teacher	SCHOOL
26.	Ms. Stella Nkansah	Principal Teacher	SCHOOL
27.	Mr. Felix Awude	Principal Teacher	SCHOOL
28.	Mr. Alfred Agyepong Kesse	Principal Teacher	SCHOOL
29.	Mrs. Mary Andoh Kumi	Principal Teacher	SCHOOL
30	Mrs. Salome Adjei Mensah	Principal Teacher	SCHOOL
31.	Mrs. Harriet Dinku	Principal Teacher	SCHOOL
32.	Mrs. Benjamin Nana Danso	Teacher	SCHOOL
33.	Mr. Isaac Lartey	Teacher	SCHOOL
34.	Ms. Selina Bluie	Teacher	SCHOOL
35.	Mr. A. O. M. Ashiaby	Principal Curator	HORTICULTURE
36.	Mrs. Olivia Lassey-Mensah	Chief Nursing Officer	CLINIC
37.	Mrs. Florence Ayin	Prin. Nursing Officer	CLINIC
38.	Mrs. Beatrice Klaye	Prin. Nursing Officer	CLINIC
39.	Ms. Grace D. Armah	Dispensing Technician	CLINIC
40.	Mrs. Violet Dzakpata	Snr. Nursing Officer	CLINIC
41.	Ms. Mercy Aboagye	Nursing Officer	CLINIC
42.	Ms. Margaret Maino	Nursing Officer	CLINIC

2.6.2 SENIOR STAFF (CONT'D)

NO.	NAME OF OFFICER	POSITION	DEPT./SECTION
43.	Mr. Albert Nani	Snr. Lab Technologist	CLINIC
44.	Mr. Felix Pinto	Laboratory Technician	CLINIC
45.	Mr. Emmanuel Addo Kusi	Principal Technician	ELECTRICAL
46.	Mr. Godwin Katamatu	Snr. Technician	ELCECTICAL
47.	Mr. A. Y. Ganey	Snr. Technician	AUTO WORKSHOP
48.	Mr. Opoku Twum	Snr. Technician	AUTO WORKSHOP
49.	Mr. J. A. Eshan	Chief Driver	TRANSPORT
50.	Mr. Jonathan Osign	Chief Driver	TRANSPORT
51.	Mr. Daniel Kwamladza	Chief Driver	TRANSPORT
52.	Mr. Theophilus Quartey	Snr. Security Officer	SECURITY
53.	Mr. I. K. Nsiah	Security Officer	SECURITY
54.	Mr. J. K. Eshun	Security Officer	SECURITY
55.	Mr. E. O. Quaye	Security Officer	SECURITY
56.	Mr. David Boyetey	Principal Works Supt.	WORKS & MAINT.
57.	Mr. Emmanuel Larbi	Principal Works Supt.	WORKS & MAINT.
58.	Mr. Michael Entsiwah	Snr. Works Supt.	WORKS & MAINT.

SECTION THREE

3.0 NATIONAL NUCLEAR RESEARCH INSTITUTE (NNRI)

3.1 INTRODUCTION

The National Nuclear Research Institute of the Ghana Atomic Energy Commission is by law responsible for taking custody of and operating all high-level, government-owned nuclear facilities in Ghana. To this end, the Institute is responsible for the safe operation of the Ghana Research Reactor-1 (GHARR-1), the Gamma Irradiation Facility, Non-Destructive Testing, X-ray and Radiography sources; as well as, a Mechanical Workshop among other devices and equipment on the campus of the Commission. In addition, the Institute operates the Radiotherapy Cancer Treatment Facility at the Korle-Bu Teaching Hospital in Accra; and, shall also be responsible for the near-to completion centre at the Komfo-Anokye Teaching Hospital in Kumasi.

For its research activities, the Institute has three departments namely: Physics, Chemistry and Nuclear Engineering and Material Science. There are also two centers, the Radiation Technology Centre and the Digital Electronics and Nuclear Instrumentation Centre. All these Departments and Centres have their requisite laboratories associated with their activities. The National Nuclear Research Institute (NNRI) has a Directorate that coordinates both the research and commercial activities of the Departments and Centres.

The main areas of research and service provision to the public include:

-
- Elemental analysis of geological materials and biological samples;
- Non-destructive testing of joints;
- Gamma irradiation leading to radiation processing of foods and
- Non-food item samples, design, production and maintenance of electronic parts, devices and equipment;
- Diagnosis and treatment of cancer by radiotherapy;
- The use of Co-60 and Cs-137 for scanning of columns of petroleum refinery; and
- An Am-Be neutron source for determination of liquid levels of hydrogenous materials.

The elemental analysis is carried out by the Analytical Group using methods like X-ray Fluorescence Analysis (XFA), Instrumental Neutron Activation Analysis (INAA) and Atomic Absorption Spectrophotometry (AAS). These methods individually or collectively enable the composition of almost all materials to be analysed to parts per million (ppm).

The non-destructive testing methods allow faults in "hidden" joints (or which cannot be seen with the naked eye) to be exposed. These methods include, high intensity X-ray and radiation sources used in a faction called radiography that is similar to X-ray diagnosis at the hospitals.

Gamma irradiation is the process by which materials are exposed to gamma source of radiation. Gamma radiation can be used to kill microorganisms in a process called sterilization, or used to modify the physical and chemical properties of materials to enhance their utilization. By this process, medical devices and disposables are

sterilized, and the shelf life of food products like spices, maize, beans, onions and yams are extended.

The Digital and Electronics Instrumentation Centre (DENIC) designs and produces electronic components for the repair and maintenance of electronic systems of the Commission and the public.

Facilities and equipment of the institute are used for manpower training of students from our universities and African researchers through the International Atomic Energy Agency's sponsored regular training programmes.

3.2 VISION & MISSION

3.2.1 VISION

2.

The NNRI aspires to become an Institution of excellence in the sub-region in the development and peaceful utilization of Nuclear Science and Technology for the welfare, safety and security of the Ghanaian society.

3.2.2 MISSION

The National Nuclear Research Institute (NNRI), exists to promote and strengthen nuclear science and technology through research, training and development for the socio-economic development of Ghana

3.3 PERSONNEL

3.3.1 NOMINAL ROLL OF NNRI

The number of employees at the Institute during the year under review stood at 95 and the distribution is as follows.

Established post	-	91
Temporary Appointment	-	4

There were forty-one (41) Scientists and twenty-eight (28) technicians who carried out the core business of the Institute.

3.3.2 TEMPORARY APPOINTMENTS

The following were also appointed temporarily: -

Miss Judith T. Addy - Typist
Miss M. Ehuman - Typist
Mr. R.E. Quagraine - Snr. Technician
Mr. J.A.K. Nsorh - Technician

3.3.3 TRANSITION

1. Mr. J.K. Prah, Prin.Technician, Chemistry Department attained the statutory retiring age.

2 Rev. (Mr.) Samual Akoto Bamford, Senior Scientific Officer, Physics Department was granted leave of absence to take up appointment at IAEA.

3. Dr. H.O. Boadu, Senior Scientific Officer, NEMS Department, was granted leave of absence to take up appointment at IAEA.

4. Mr. Patrick Tawiah, Technician, NEMS Department, resigned from the Service and the Commission.

5. Mr. Christian Debrah, Scientific Officer, Chemistry Department resigned after going on leave without pay for two years.

3.3.4 VACATION OF POST

1. Ms. Theresa Osei-Bonsu, - Steno. Secretary NEMS Department.

2. Mr. Richard Osei-Owusu, (Technician) DENIC.

3.3.5 STUDY LEAVE/FELLOWSHIP

The following members of staff were on study leave or fellowship during the period under review.

Name	Country
1. Mr. G.K Banini	U.K.
2. Mr. M. J. Akudugu	South Africa
3. Mr. D.N.A. Amoo-Dodoo	U.S.A
4. Mr. J. B. Pratt Awotwe	U.K
5. Mr. S. Anim-Sampong	Italy

3.3.6 DEATH

The Institute lost one member of staff at the Mechanical Workshop by name Mr. David Ametepey (Dept. Asst. II). May his soul rest in peace.

3.3.7 PROMOTION

Mr. J. K. Gbadago was upgraded from the rank of Assistant Scientific Officer to Scientific Officer after obtaining his M.Phil (Physics) degree from the University of Ghana.

3.4 MAJOR RESEARCH FACILITIES

3.4.1. NUCLEAR ENGINEERING AND MATERIAL SCIENCE DEPARTMENT

(i) Ghana Research Reactor-1 Centre

The Centre operates a 30 kW tank-in-pool reactor designed mainly for neutron activation analysis, production of short-and medium- lived radioisotopes for radiotracer technology. The reactor complex consists of the reactor, control systems (console and micro-computer), two pneumatic transfer systems, gas purge system, water purification systems, de-ionized production system and air-compressor unit.

The Neutron Activation Analysis Laboratory has two gamma-ray spectroscopy systems with appropriate software for spectrum analysis to determine qualitatively and quantitatively the elemental composition of any sample with different origins.

The sample preparation room is equipped with a modern freeze dryer, microwave digestion system, water-baths, centrifuge and automatic ovens to support effective research and commercial activities.

To ensure reactor safety and personnel monitoring the Centre is also equipped with Health Physics Monitoring equipment such as hand and foot monitor, gamma, beta and alpha hand monitors and contamination monitors.
It has an Instrumentation Laboratory for repair and maintenance.

A modern hand-and-foot monitor is installed for the monitoring of personnel working at the Centre and for the numerous visitors. There are hand monitors to detect the levels of radiation associated with irradiated samples and monitoring of radiation within the laboratories, offices and the environment.

(ii) Radioisotope-based Technology Laboratory

The laboratory has gamma emitting sources such as Co-60 , Cs-137 which are used for the scanning of columns of petroleum refinery and an Am-Be neutron source for the determination of liquid levels of hydrogenous materials. The laboratory is equipped with facilities for measurement of liquid and gaseous flow rates and for residence time distribution (RTD) of various unit operations of chemical industries.

(iii) Non-Destructive Testing Laboratory

The laboratory is equipped with NDT equipment for four methods of testing: radiographic testing (RT), ultrasonic testing (UT), magnetic particle testing (MT) and liquid penetrant testing (LPT).

(iv) Mechanical Workshop

The Machine and Fabrication Shops have some advance and sophisticated equipment to support the manufacture of various industrial and agro-based equipment items.

3.4.2. CHEMISTRY DEPARTMENT

The major research facilities available in the Department are

(a) Atomic Absorption Spectrophotometer for Environmental Analytical Chemistry Division,

(b) Electrophoresis equipment, UV-Visible spectrometer, Lypholizing equipment in the Radiopharmacy Division, and

(c) two Gas Chromatography machines are yet to be rehabilitated to enable the Pesticide Residue Group to perform their research in the Department.

3.4.3. PHYSICS DEPARTMENT

Facilities at the Physics Department include:

* X-ray Fluorescence Laboratory with X-ray tube source for the excitation of materials and computer software for elemental analysis.

* Neutron Activation Analysis equipment: This comprise of MNSR reactor and computer software for elemental analysis. The two equipment items are complementary and are jointly manned by the Physics Department and the Reactor Centre.

* The Solid State Nuclear Track Detection Laboratory: The equipment available are plastic detectors for the detection of heavy ionizing radioactive elements and a spark counter and optical microscopes for the count of trades produced. Also available are furnaces for the annealing of rock samples for track dating.

- Medical Physics Unit has a computer-based treatment planning system and equipment for checking radiation doses to patients. There is also a gamma facility for cancer treatment. These are located at Radiotherapy Center at the Korle-Bu Teaching Hospital.

3.4.4 DENIC

(i) Instrumentation laboratory:

This is a laboratory where electronic equipment are built and tested prior to mass production. It is also used for maintenance and repair of electronic equipment.

(ii) Printed Circuit Board Milling Machine:

This machine allows the physical detection of an electronic circuit design. When the finished PCB is propagated with an electronic component, it is tested and packaged to produce a working elelctronic equipment.

(iii) Microprocessor Training Kit:

The microprocessor machine is used in teaching computer architecture and basic Assembly Language, a machine level language also known as firmware. This is normally embedded in mircoprocessor-based equipments.

(iv) Digital Oscilloscopes:

This is used to take proper electronic signals and also an aid to test faulty electronic equipment.

3.3.5 RADIATION TECHNOLOGY CENTRE (RTC)

The major facilities at the Centre are the Multipurpose gamma irradiation facility and the Gammacell-220 equipment for radiation processing.

Two spectrophotometers are also available for radiation dose evaluation, which is prerequisite for radiation processing activities.

3.4 SUMMARY OF RESEARCH WORK OF NNRI

The summaries of the research findings of individual scientists at the Institute for the year 2001 are presented in this section.

3.5.1 RESEARCH ACTIVITIES AT NUCLEAR ENGINEERING DEPARTMENT

(a) Simultaneous use of neutron transmission and reflection techniques for the analysis of crude oil samples.

E.H.K. Akaho, S.A. Jonah, B.J.B. Nyarko, S. Osae, Y. Serfor-Armah, A.W.K. Kyere.

Neutron attenuation and reflection characteristics of three crude mineral oils from West Africa were determined using 1 Ci Am-Be source in a single set-up and compared with those of paraffin (oil) and benzene, an aromatic compound. Analytical expressions were derived for the calculation of transmission and reflection parameters for various thicknesses of the hydrogenous samples. Based on the trend of measured data and constants as well as exponents of equations which are similar to those exhibited by paraffin but different from values associated with benzene, the crude oil samples can be characterized as paraffinic. The total hydrogen H, and ratios (O+C)/H and C/H determined for the crude oil samples using the transmission and reflection techniques are not only independent of the technique but are also consistent with literature values of thermal reflection.

(b) Application of two standardization methods of neutron activation analysis technique for the multi-elemental analysis of tropical honey

E.H.K. Akaho[1], B.J.B. Nyarko[2], Y. Serfor-Armah[3], S. Osae [2] B.T. Maakuu[1], S. Anim-Sampong[1]*

Multi-elemental analysis was carried out for a tropical honey produced in an oil palm plantation using Improved Absolute Method (IAM) and k_0-standardization method of neutron activation analysis (NAA) technique. A total of sixteen (16) chemical elements were determined in the sample. Out of these, K and Cl had the highest concentrations of 1010 and 285 ppm respectively. Other elements in decreasing order of concentrations were: Ca, Mg, Al, Cu, Fe, Na, Zn, Rb, Br, Co, Mn, As, Sb and Sc. Most of the elements found in the tropical honey are essential to the human body and play vital role in human health and nutrition. The precision and accuracy of the two NAA methods have been evaluated and found to be in good agreement.

(c) Characterization of neutron flux spectra in irradiation sites of Ghana MNSR using Westcott-formalism for k_0-NAA method

E.H.K. Akaho[a] and B.J.B. Nyarko[b]*

For the general applicability of k_0-NAA method to deal with "non-1/v" (n,γ) reaction

nuclides, the modified spectral index $r(\alpha)\sqrt{(T_n/T_0)}$ and $g(T_n)$ factor for monitoring neutron temperature T_n for the inner and outer irradiation sites of Ghana MNSR (GHARR-1) were measured using the Cd ratio method. Using the measured cadmium ratio for lutetium and the modified spectral index the reduced resonance integral of lutetium $s_{0,Lu}$ was also calculated. The computed result of 1.64 was in good agreement with the reported value of 1.67 in nuclear data. Based on the assumption that the definitions of reaction rates of Westcott-formalism and Nisle's unified formulation are equal, theoretical verification of the accuracy of the measured modified spectral indices for our data and those reported for other research reactors in literature was carried out. Employing ^{197}Au, ^{96}Zr and ^{94}Zr as "1/v" monitors, the theoretical values which depend on the choice of the monitor, followed the trend for measured values of sub-cadmium to epi-cadmium flux ratio f for nine irradiation sites of four different research reactors. The computed and experimental modified spectral indices for different flux ratios associated with irradiation sites within the range 18.8 - 152 fitted well to a simple exponential relation. Calculated and measured data are in good agreement when appropriate correction factors are used.

(d) Evaluation of EPI factors of Hogdahl-and Westcott - formalisms for "non-1/v" (n,γ) nuclides using k_0-standardisation NAA method

E. H. K. Akaho[a,], B. J. B. Nyarko[a], R. Acharya[b,c], A. Chatt[b]*

Based on the assumption that (n,γ) reaction rate at irradiation sites predicted by Hogdahl-, Westcott- and Nisle- formalisms are equal, expressions were derived for the modified spectral index $r(\alpha)\sqrt{(T_n/T_0)}$ and used to obtain EPI factor needed for calculating the concentrations of elements using k_0- standardization NAA method. Good agreement was observed between calculated modified indices with experimental data for nine irradiation sites of four different reactors for "1/v" (n,γ) nuclides with high Q_0 values whilst no clear trend was followed by "non-1/v" nuclides. The theoretically predicted effective activation crosses section at the irradiation sites for "non-1/v" nuclides, ^{176}Lu, ^{151}Eu and ^{164}Dy compared favourably with nuclear data available in literature. Furthermore, it has been shown mathematically that the EPI_H factor based on flux parameters (f and α) of Hogdahl-convention is equal to the factor EPI_W using the parameters ($r(\alpha)\sqrt{(T_n/T_0)}$, $g(T_n)$ and $s_0(\alpha)$) of Westcott-formalism. The maximum deviation between the computed EPI_H and EPI_W is only 5.94% suggesting that the present method of analysis could be useful for k_0-NAA to cover both "1/v" and "non-1/v" (n,γ) nuclides.

(e) Screening of some commonly used skin-lightening creams and soaps: A Case study in Ghana.

B.T. Maakuu, C.T. Beni, B.A.M. Baudowe, E.H.K. Akaho

Six commonly used skin lightening creams (Body Claire, Akagni, Sivoclaire, Topgel, Tenovate Movate and Peau Clair) and five medicated soaps (Tura, Sukisa Bango, Crusader Safety, Movate Germicidal and Siver Rose) were investigated for their hazardous effects on the skin. Instrumental Neutron Activation Analysis (INAA) was used to identify and quantify the levels of trace/heavy metals in these creams and soap samples. The analysis showed the presence in the creams of significant concentrations of Mn, Cd, Au, Cu, Sn, In, Sc, Hf, Eu, Ta, Ba, Nd, Sb, Al, and Co. The medicated soaps contained significant concentrations of Hg, Co, Ce, Al, Hf and Ti. Thin layer Chromatography (TLC) investigations revealed the presence of hydroquinones in the Akagni and confirmed its presence also

in Body Claire, Peau Claire and Sivoclaire but its absence in Tenovate, Topgel and Movate creams. Titration of the creams against Ce(IV) solution showed hydrquinone levels of 2.47% in the Body Claire, 4.92% in Akangi and 4.03% in Sivoclaire. These levels were found to be higher than the maximum of 2% allowed by the Ghana Standards Board, the EEC directives of 1976 and the Cosmetic Production Regulation 1978 (UK) for product safety.

(f) Three-Dimensional Monte Carlo Modeling and Particle Transport Simulation of the Ghana Research Reactor-1

S. Anim-Sampong, E.H.K. Akaho, N. Burgio, A. Santagata

Stochastic Monte Carlo methods have been applied to successfully develop a 3-D Monte Carlo model of the HEU-fueled Ghana Research Reactor-1 using the versatile and powerful MCNP4c3 particle transport code. The preliminary Monte Carlo criticality calculations yielded a keff=1.00449 with a corresponding cold clean excess reactivity of 4.47mk (447pcm) compared with experimental values of keff =1.00402 and excess reactivity 4.00mk (400pcm). The Monte Carlo simulations also show comparable results in the neutron fluxes in the HEU core and some regions of interest. The observed trends in the radial and axial flux distributions in the core, beryllium annular reflector and top shim tray water were successfully reproduced, indicating that the Monte Carlo model is good and the simulations comparable and in close agreement with experimental measurements conducted during off-site zero power and on-site cold tests.

3.5.2 RESEARCH ACTIVITIES AT THE CHEMISTRY DEPARTMENT

(a) Studies on depletion of Atrazine and Simazine in two soil ecosystems.

S. A. Afful and Yeboah P.O

Two soil ecosystems, coastal savanna and forest zone, where food and cash crops receive much commercial cultivation in Ghana, were used in the investigation because of urgency and also for comparative purpose. Analysis of the depletion data indicated that the herbicides slightly depleted faster in the forest zone soil as compared to the coastal savanna soil. It was also established that the higher soil moisture and organic matter content facilitated the relative faster depletion of the herbicides in the forest zone soil. In all, simazine depleted faster than atrazine.

(b) Study of effect of irradiation on the stability of locally manufactured drugs

Mr. S. A. Doghe

The objective of the study was to evaluate the feasibility of radiation sterilization of some locally manufactured drugs (aqueous sodium chloride for intravenous transfusion, procaine penicillin, chloramphenicol eye ointment and codein phosphate). The drugs were examined for changes in colour, pH and UV-absorption spectra. The optical absorbance and pH of the drugs studied were found to decrease slightly after exposure to 20 kGy radiation dose and above. Slight colour change was also observed at 30 kGy radiation dose in the codein phosphate and chloramphenicol eye ointment. The viscosity of the eye ointment was also found to decrease significantly with irradiation dose. These observations could be attributted to some amount of chemical instability of the drugs, especially at irradiation dose above 25 kGy.

(c) Determination of Cu, Pb, Mn, Cd, Cr, and Zn in waste water from car washing by Flame Atomic Absorption Spectroscopy (FAAS).

Mr. S. A. Dogbe

The pH values of waste waters collected from car washing stations in Madina and Adenta were found to be between 4.7 and 8.3 with the majority of the samples being acidic. With the exception of Pb, which was not determined, appreciable levels of all the metals were found in the wastewaters as follows:

Cu (mg/l):	20.35 – 25.10
Mn (mg/l)	120.40 – 312.70
Cd (mg/l)	0.24 – 0.48
Cr (mg/l)	4.28 – 6.88
Zn (mg/l)	56.73 – 108.38

The results suggest that car washing stations could contribute significantly to metal pollution of the environment, especially during prolong period of discharge.

(d) Establishment of a Molecular Biology Laboratory for the diagnosis of tuberclosis in Ghana.

I.K. Wilson and Oti K. Gyamfi

Samples obtained from Korle Bu Teaching Hospital were subjected to the polmerase chain reaction (PCR). Out of 63 smear negative samples, 34 were PCR positive; 29 were PCR negative. Of the PCR positive samples 13 were culture positive and 21 were culture negative. Nine out of the PCR negative were culture positive. This fact corroborates the observation that the decontamination procedure which is optimal for culture may not be optimal for PCR.

(e) Seaweeds as bioindicators for monitoring toxic element pollutants in the marine ecosystem of Ghana.

Yaw Serfor-Armah

Fourteen seaweed species were sampled along the rocky coast of Ghana, which is being washed by the Gulf of Guinea, with the basic aim of selecting suitable seaweed species for bio-monitoring. Six towns were selected for the study; these were Prampram, Nungua, Winneba, Cape Coast, Sekondi and Axim. Five (5) chlorophyta, three (3) phaeophyta and six (6) Rhodophyta species were studied.

The characterization of the phycocolloids, which is believed to complex the heavy metals from the environment, is being studied. Project is on-going.

(f) Determination of essential trace elements in some Ghanaian traditional plant medicines.

Yaw Sarfo Armah, etal

Some essential elements in 11 plant medicines used at the Center for Scientific Research into plant Medicine (CSRPM), Mampong-Akwapim, Ghana, for the management and cure of various diseases were determined by Instrumental Neutron Activation Analysis (INAA), using thermal neutrons at a flux of 5×10^{11} n^{s-1} cm^{-2}. The plant medicines were: Sirappac powder-E, Tina-A powder, Blighia powder, Aphrodisiac powder, Momordica powder, Kenken and Fefe powders. Concentrations of 17 elements namely Al, Br, Ca, Cl, Co, Cu, Cr, Fe, K, Mn, Mg, Na, Rb, Sb, Sc, Ta, V and Zn have been determined by short, medium and long irradiations of these elements. Co, Sb, Cr, Mn, Rb, V and Zn were determined at the minor level, while Al, Fe, Ca, Cl, L, Mg and Na were generally at the major level. These elements are important for human health and nutrition.

The Project is on going.

(g) Insecticide use patterns on vegetables and analysis of residue levels in tomatoes and onions

P.O. Yeboah

Persistent organochlorine pesticides constitute between 13.3 and 23 % of insecticides being used by farmers for the control of pests in the major tomato growing areas in the Brong Ahafo and the Upper East regions of Ghana. Most of the tomato farmers were not well informed on safe use of pesticides, and applied pesticides incorrectly, thus polluting their farm produce and the environment

The results confirm speculations and concern of many that hazardous chemicals are still being used on food crops in Ghana

Residue levels of these organochlorine insecticides (Lindane and endosulphan) on fresh tomatoes were determined and found to be below FAO/WHO maximum residue levels (MRLs), whereas residues levels of chlorpyrifos on tomatoes were found to exceed FAO/WHO MRLs

These findings underscore the need for Ghana to develop the capacity and capabilities for routine monitoring of residue levels to ensure consumer safety.

(h) Chemical Basis for nuclear waste management:Environmental Impact Assessment.

James H. Ephraim

Results obtained from the characterisation of the various fulvic acid samples isolated in Ghana corroborate the assertion that fulvic acids in the tropics have similar characteristics as those extracted from the temperate regions. The significance is the fact that data generated in the temperate regions involving fulvic acids could appropriately be employed for fulvic acids in the tropics. Results from the impact assessment show that the activities of small-scale mills at Kade have significant negative impact on the environment, even though they are not required by law (LI 1652) to perform an impact assessment.

3.5.3. RESEARCH ACTIVITIES AT PHYSICS DEPARTMENT

The research activities undertaken during the year in the Physics department at the various sections are:-

a. X.R.F. LABORATORY

The Laboratory has been involved in a

1) Bi-National Environmental and Quality Control.

This is a joint I.A.E.A. Technician Co-operation project between Ghana and La Cote d'Ivoire. Targets achieved under this were

i. Baseline Meteorological data Analysis
ii. Receptor Modelling, Source Apportionment and plume modelling.

2) Bio Monitoring of Air Pollution through Trace Element Analysis

This is an I.A.E.A. Coordinated Research Program.

b. THE NEUTRON ACTIVATION ANALYSIS UNIT

The unit is basically involved with the use of neutrons generated with the Miniature Neutron Source Reactor (MNSR) at the GhARR-1 Centre for elemental analysis in geological, medicinal and biological samples. It is an interdisciplinary group.

One of the projects being proposed by the group is a Geo-chemical Mapping of Ghana.The project would produce the elemental signature of the topsoil for the major geological formations in Ghana.

Some studies undertaken during the year were:-

1. Study of the Buem Formation in Eastern Ghana
2. Major Element Compositional Variation in ant-hills
3. Determination of Essential Trace Elements in some Ghana plant medicine
4. Crude Oil Analysis

B.J.B. Nyarko

Research area includes:- Elemental Analysis and Characterization of materials using Nuclear related techniques, Radiation measurements, gamma-ray spectroscopy and neutron physics.

1. Work carried out or ongoing included:

Iodine in foods and diet: thermal and Epithermal neutron activation analysis have been used to analyse several salt and food samples in Ghana for Iodine. The values of Iodine determined in iodised salts range between 10.0 and 210ppm. For non-iodinated salts, iodine levels were below 500ppb. Assessment of the iodine status of Ghanaian children and of their daily dietary intake of iodine is ongoing. The overall objective of this project is to estimate the iodine status of Ghanaian children who are most vulnerable to Iodine Deficiency Disorder (IDD). The project is in collaboration with the Nutrition Unit of the Ministry of Health.

2. Bio-monitoring Air Pollution through Trace Element Analysis.

The atmospheric matrix is the least investigated amongst the environmental matrices studied in Ghana so far. Besides, there is no Publication (locally or otherwise) on biomonitoring air pollution in Ghana. Work is ongoing to investigate the potential and reliability of indirect monitoring of heavy metal pollution in ambient air using local lichens and mosses in mining and industrial areas in Ghana.

3. Characterization of Neutron Flux Spectra

Neutron Flux Spectra in irradiation sites of MNSR reactor using the Westcott-formalism for the ko-NAA analysis method has been carried out for the general applicability of the method to deal with "non-1/V" (n, γ) reaction nuclides. The modified spectral index r (α) ----(To/Tn) and g(Tn) factor for monitoring temperature T_N for the inner and outer irradiation sites of the Ghana MNSR reactor (GHARR-1) were measured using the Cd-radio method.

c) SOLID STATE NUCLEAR TRACK DETECTION GROUP

During the year, the Group entered into a protocol agreement with the Seismology Section of the Geological Survey Department (GSD) of Ghana for joint research in Radon gas Emission and it's correlation with seismic activity. The sampling sites are the seismological stations of the Geological Survey Department. Data collection is ongoing.

The group had enquiries from various estate developers for the evaluation of soil radon gas activity at their building sites. A preliminarily report for one such study was prepared for Akins Properties Limited for their Bortianor site. The final report is yet to be prepared.

The group has the view of preparing a radon map of Ghana, this would help in the location of possible uranium ore deposits and the types of rock formation to be associated with uranium ore.

d) MEDICAL PHYSICS GROUP

This group continued with their usual activities at the Radiotherapy Unit of the Korle Bu Teaching Hospital. This involved treatment planning for the numerous cancer patients that were treated at the Korle Bu Teaching Hospital during the year.

3.5.4. RESEARCH ACTIVITIES AT THE DIGITAL ELECTRONICS AND NUCLEAR INSTRUMENTATION CENTRE (DENIC)

a) Design and Development of Electronic Display Board.

P. K. Obeng, and E. Boadu.

The objective of this research is to develop a giant Electronic display board that will indicate the time, temperature, and humidity of the day with a flashing "GAEC" around it. The board when completed will be mounted in front of the GAEC administration.

b) Design and development of an inventory-based system for the Commission stores and petrol station.

P. K. Afriyie.

A system that collates data on sale of fuel for the Commission and its Institutes and generates report for administrative purposes was designed and developed. This replaces the old system of filling cards and manual calculations.

c) Construction of a Microprocessor based power conditioner (phase-2)

P. K. Obeng.

The phase one of the project was to design and develop a microprocessor based power conditioner, which was successfully carried out in 2000. The second phase of the project is to manufacture a workable conditioner for testing and possible commercialisation.

d) MAINTENANCE ACTIVITIES

i. KORLE-BU TEACHING HOSPITAL

There was a major rehabilitation work on the Gamma Camera at the Korle-Bu Teaching Hospital this year. The rubber coupling gear that translates the turning of the electric motor to the vertical movement of the head (detector) got chopped off, thus even though the motor was turning, the head was not moving. The other problem with the camera was that, the limit (micro) switch that determines the maximum height the head can go got spoiled and that made the head get stuck at the top of the camera.

During the year, an Ortho Voltage X-ray generator was installed at the Nuclear Medicine Centre at Korle –Bu.

ii) INSTITUTES UNDER GAEC

The Mechanical Section of NNRI constructed a special crane that was used to lift the head from the vertical stand to a flat platform. The micro switch and the gear were replaced with the ones the IAEA ordered from MEDX. The stand was then greased and the head was put back. Some electronic boards were repaired. Alignment was performed and QC pictures were taken using the ANUGAMI (Indian) acquisition card. The camera is now in good condition and clinical studies can now begin in earnest

DENIC also repaired other scientific equipment, computers, monitors, and stabilizers, which were sent from the Institutes under GAEC and elsewhere.

3. 5.5 RESEARCH ACTIVITIES AT RTC

Research activities carried out during the period under consideration are listed below.

a) Determination of Dose Levels for Some Commodities

G. Emi-Reynolds, G.K. Banini and Isaac Ennison

Status: On-going

This project is centred on the determination of the radiation decontamination dose and the dose distribution within the packaging of some commodities treated at the Centre. The commodities are local herbs and spices with some intended for export. It is required internationally that the minimum and maximum doses accepted for the treatment of commodities be adhered to. The work is also carried out to ensure that the dose distribution in a given product falls within the required dose range. An estimation of the dose distribution within the carriage after a complete cycle irradiation has been obtained for different products of different densities.

b) Design of Conveyor System for the Gamma Facility

I. Ennison, G. Emi-Reynolds, P. K. Obeng, P. K. Afriyie and A. Mahamah.

Status: On going

As part of efforts to upgrade the gamma facility, a conveyor system is needed for the loading and off loading of goods. This is to increase the output of the treatment of goods in the facility. A conveyor system being designed is to be built locally for the facility. The mechanical and electronic design commenced in the caurse of the year.

c) Radiation Stability of Packaging Materials

G. Emi-Reynolds, G.K. Banini and I. Ennison

Status: On going

In connection with the commercial activities of the RTC, products to be treated and their packaging (eg. polymers and plastics) are subjected to intense radiation doses and the stability of the materials determined. It has been established that above 10 kGy, some physical and mechanical properties of some polymers are affected due to cross-linking and polymerisation. The effect may tend to improve the quality of the product or rather have negative effect on the material with ageing. In the present work, the materials being investigated for the past two years have been the intravenous infusion sets and their packaging.

d) Radiation Processing of Rubber

G. Emi-Reynolds, S. A. Dogbe and I. Ennison

This project involves treatment of natural rubber treated with radiation to improve its strength. The combination of known vulcanisation and radiation treatment of natural rubber shall also be studied.

3.6 COMMERCIALISATION

Commercialisation activities were undertaken by various departments and units under the Institute. These include:

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(i) Multi-elemental Analysis of Geological and Industrial Samples

The reactor's stable neutron flux of $1x10^{12}$ $ncm^{-2}s^{-1}$ at inner irrradiation site at maximum power of 30kW is very ideal for multi-elemental analysis. Trace elements of very low concentrations in ppb can be determined with very high accuracy and precision. The reactor is not only used for research, it is also used for commercial

irradiation of samples for quality control. Various industries, research institutes, local and foreign universities continue to use the reactor and its facilities. Out of the 3100 samples irradiated during the year, a third were commercial samples. Apart from private individuals who were interested in the analysis for gold, titanium and niobium, sample analytical services were rendered to companies such as Tema Oil Refinery and Ghana Standards Board.

(ii) RadioisotopeTechnology application in Petrochemical Industry

Engineers and Technicians of the Radioisotope-based Technology Section carried out series of gamma-ray scanning of the crude, stabilizer and splitter columns of Tema Oil Refinery (TOR).

(iii) Nondestructive Testing in Industries

Trained personnel offered NDT services to various companies in Ghana including: refinery, thermal power plants, shipyards, petroleum companies and both government and individual companies. Some of the companies which benefited from the services of the NDT Section are Aluworks, Ghana Oil Company, Tema Oil Refinery, Inspectech Engineering Quality Services (IEQS), Shell Ghana Limited, PSC Tema Shipyard Company Limited, Crocodile Engineering Services, Lever Brothers (Gh.) Limited and Ghana National Petroleum Corporation.

(iv) Manufacturing and Fabrication of Machines and Equipment

The Mechanical Workshop has a mechanical engineering design office which supports activities undertaken at the workshop. Individuals and institutions collaborate with the well-trained and experienced staff to manufacture equipment to meet required specifications.

Commercial activities such as construction of gas ovens, fabrication of washer cutting machine, turning and milling of engine blocks, fabrication of mild steel mould trommel for mining etc are carried out at the Workshop.

Facilities available at the fabrication shop are used by the staff of the National Service and engineering staff of Christo Asafo Church for the manufacture of various items and equipment.

(v) Refrigeration and Air Conditioning Services

Staff of this Unit install, repair and maintain the equipment associated with air conditioning and refrigeration for the Commission's laboratories and offices. Installations of equipment were also carried out for interested individuals and organizations.

vi) The Environmental Analytical Chemistry Division has been engaged in the analysis of samples from Panbros Salt Industry, Weija-Accra.

vii) The Radiopharmacy Division was involved in PSA and AFP analyses at the Korle Bu Radiotherapy Centre as part of our commercialisation venture.

viii) The Glass-Blowing Unit was involved in the repairs of glassware for second cycle schools in Ghana as an integral part of the Chemistry Department's commercialisation activity.

ix) The Physics Department provided analytical services to industries in the field of environmental monitoring at the Tema Oil Refinery by the X-ray Flouresence Laboratory.

x) Crude Oil Analysis for trace elements such as vanadium was also done for the

Tema Oil Refinery by the Neutron Activation Analysis Laboratory.

xi) The S.S.N.T.D Laboratory provided on-site soil radon activity measurements for some estate developers.

xii) The Medical Physics Group provided cancer treatment planning services at the Nuclear Medicine Centre at the Korle –Bu Teaching Hospital.

xiii) Radiation Technology Centre (RTC)

From the beginning of the year, the gamma irradiation facility of the RTC, which had broken down, was repaired by a technical team from Hungary together with the local team. The irradiator was restored back to work on 8th March, 2001. Food items such as yam, onions, meat, ginger, coconut etc. from the various research institutions were treated. Research institutions like the Biotechnology and Nuclear Agriculture Research Institute (BNARI), Animal Research Institute and Oil palm Research Institute among others brought research samples for irradiation.

In addition to the research, certain food items and medical products were treated on a commercial scale. These were pepper, shrimp powder and ginger powder as well as infusion administrative sets. Yams, pineapples and some local herbs were also brought in for radiation treatment. In addition, surgical products from the Amasaman Health Centre meant for the treatment of buruli ulcer were sterilised.

In preparation for the upgrading of the facility and to identify more clients, a questionnaire was developed and sent round to potential users from industry. The outcome of the investigation is that in collaboration with the Ministry of Trade and Industry and the Ghana Export Promotions Council, a day's workshop is going to be organised to educate industrialists and the general public on the benefits of radiation processing.

3.7 PHYSICAL DEVELOPMENT

The Department of Chemistry lacks all the physical development that a Chemistry Department requires to enable it undertake meaningful research. After relocating the Department into its present building, benches, fume hoods and all other infrastructure have not been provided due to lack of funds. This situation obviously does not augur well for the Department in its quest to become a leading centre of excellence for research.

3.8. HUMAN RESOURCE DEVELOPMENT

i) Lecturing and Supervision of Students' Projects/Theses

The Institute through the following Scientific Officers supervised the theses of Undergraduate and Postgradate Students at the three major Universities of Ghana. The Officers also lectured at these Universities during the period under review.

- Prof. James Ephraim - Part-time lecturer at University of Ghana, Supervised two M.Phil Students at the University of Cape Coast..

- Dr. P.O. Yeboah - Part-time lecturer at University of Ghana. Supervised two M.Phil Students and two Ph.D Students from Univerisity of Ghana. One M.Phil Student from Kwame Nkrumah Univerisity of Science and Technology is still being supervised.

- Mr. B. T. Maakuu and Prof. E.H.K. Akaho continued to serve as Part-time Lecturers of Department of Physics.

- P. K. Obeng delivered lectures on "Computer Programming" at the 3rd Training Course organised for Mathematics Teachers at the Secondary School Level by the National Centre for Mathematical Sciences, 23 July - 2 August, 2001.

- The Scientific Staff of DENIC also supervised the construction and testing of projects of final year students of Cape Coast University, Accra and Takoradi Polytechnics.

- Staff of the Physics Department supervised university student projects in reactor physics and neutron activation analysis. In all, two projects from the University of Cape Coast and 1 M.Phil project from the University of Ghana were made using the research reactor.

- Three technicians and three National Service Persons were trained at the Mechanical Workshop and GHARR-1 Centre.

ii) Locally Organized Training Courses

In the course of the year, some training courses were organized locally. They included:-

The NDT Section organized a two-week training course in welding from 6-17 August 2001 for three welders from Lever Bothers (Gh) Limited.

The Chemistry Department organised the 13th Annual Conference of the Ghana Chemical Society 11- 13 October 2001. All Staff at the Department participated in the organisation.

A training workshop was also organised for five Nigerian Scientists on Radiation Processing Technology, 5 November - 6 December, 2001. It was meant to equip the Nigerians with the necessary scientific and technological skills to enable them operate an industrial scale multipurpose gamma irradiator currently under construction in Nigeria.

iii) Training Courses/Conferences/ Workshops/Seminars

In the course of the year, various staff members participated in the following fellowships, training courses, international scientific meetings, conferences, workshops and seminars:

(a) Mr E. Y. Amoakohene, a senior technician in the NDT Section participated in a IAEA training course on Fabrication of Non-Destructive Testing (NDT) Test Specimens at South African Institute of Welding (SAIW) in Johannes-burg, 12 – 16 November, 2000.

(b) Ms. P.S. Adu, and Prof. E.H.K. Akaho attended the AFRA Regional Conference on Research Reactors for Socioeconomic Development in Pretoria from 14 – 16 March 2001 in South Africa where four scientific papers were presented on the utilization of the reactor.

(c) Ms. P.S. Adu participated in the Regional Training Course on the Production, Use and Transportation of Radioisotopes Br-82 and Ar-41, Cairo Egypt, 12 – 23 May, 2001.

(d) Mr. B. T. Maakuu attended a Workshop on Advanced Nuclear Power Plant Simulation organized by International Centre of Theoretical Physics, Trieste, Italy, 29 October – 9 November, 2001.

(e) Mr. S. Anim-Sampong is currently on the Abdus Salaam International Centre of Theoretical Physics Training and Research in Italian Laboratory (TRIL) Fellowship for 12 months starting from 10 May 2001 at ENEA, Casaccia, Rome, Italy.

(f) Mr. Y. Serfor-Armah, AFRA Training Course, Pretoria, South Africa, 16 – 27 July, 2001.

(g) Mr. Y. Serfor-Armah,22nd Biennial Conference of GSA, Cape Coast, Ghana, 5 – 9 August, 2001.

(h) Dr. I. K. Wilson, Final review of Tumor Marker Project (RAF 6018), Algiers, Algeria, 19 – 26 October, 2001.

(i) Mr S.A. Dogbe, 13th Annual Conference of the Ghana Chemical Society, GAEC, Accra, 11 – 13 October, 2001.

(j) Dr. P. O. Yeboah, Danida-sponsored study-tour of Pesticide Laboratories in Denmark, 29 August – 7 September, 2001.

(k) Dr. P. O. Yeboah, 13th Annual Conference of the Ghana Chemical Society, GAEC, Accra, Ghana, 11 – 13th October, 2001.

(l) Prof. J. H. Ephraim, 22nd Biennial Conference of GSA, Cape Coast, Ghana, 5 – 9 August, 2001.

(m)Prof. J. H. Ephraim, 13th Annual Conference of the Ghana Chemical Society, GAEC, Accra, Ghana, 11 – 13 October, 2001.

(n) Prof. J. H. Ephraim, Workshop on Hazardous Waste Management, Pretoria, South Africa, 16 – 23 November, 2001.

(o) Mr. O. K. Gyamfi, A four-month fellowship at the Department of Medical Biochemistry, University of Stellenbosch, South Africa, February – June, 2001.

(p) Mr. P. K. Afriyie attended an AFRA training course on "Switch Mode Power Supplies". Zambia, Tanzania, 5-23 November, 2001.

(q) Mr Isaac Ennison, International Committee on Future Accelerators (ICFA) Instrumentation School, The National Accelerator Centre, Cape Town, South Africa, 26 March – 8 April, 2001. The school was organised jointly by (ICFA) and the National Accelerator Centre (NAC) of South Africa 2001. The programme centred on the semiconductor detectors, modern x-ray imaging systems, neutron therapy etc.

(r) Mr Isaac Ennison and Mr E. A. Quarcoo of RTC participated in IAEA Training workshop on Good Management Practices for Optimal Utilization of Radiation Facilities, Accra, Ghana. 14 to May, 2001. Topics treated included Industrial Applications of Ionising Radiation, Good Management Practices in Radiation Facilities, Modern Management Principles, Identifica-tion of Market for Industrial Radiation Processing and The Role of Irradiator Design Parameters on the Optimal utilisation of an irradiation facility.

(s) Mr. E. Mornoh of DENIC returned to Ghana after an eight-months IAEA fellowship training at the IAEA Instrumentation Labs, in Seibersdorf, Austria. His presence is being felt at the centre as he has already repaired a number of monitors and power supplies.

(t) Prof. E. H. K. Akaho participated in the AFRA Project Co-ordination Meeting on Utilization of Research Reactors, Pretoria, South Africa, 12 – 14 March, 2001.

The group leader in the XRF laboratory took part in the first Research Co-ordination meeting on In-situ application of XRF Techniques, Vienna, Austria, 12 – 16 March, 2001.

A member of the NAA laboratory attended a conference on Utilization of Research Reactors for Socio-economic development in Pretoria, South Africa, 14 – 15 March, 2001.

The members of the group attended a Regional Training Course on Experimental design and Sampling methodology for Geological Resources, Soil fertility and Environmental Pollution Mapping, Pretoria, South Africa, 16 – 27 July, 2001.

A member of the Medical Physics group attended the following meetings:-

1. International Conference on the Radiological Protection of Patients, Malaga Spain, 26 - 30 March, 2001.
2. First Congress of the African Oncology Group, (AFROG) Marrakech, Morocco, 12 – 13 November, 2001.
3. I.A.E.A. Task Force Meeting on Medical Radiation Physics Bloemfontion, South Africa, 18 – 22 June, 2001.
4. I.A.E.A. Coordination meeting on Strengthening Regional Capability in Medical Physics Marrakech, Morocco, 14 – 16 November, 2001.

iv) Degree Courses

Some members of the department have enrolled in various universities to do graduate studies at the Ph.D. level.

Mr. I. J. K Aboh, University of Ghana, Legon-Accra, Ghana.

Mr. O. C. Oppon, University of Cape Coast, Ghana.

Mr. T. Sackey, University of Cape Coast, Ghana.

Mr. B. Awotwe Pratt is pursuing a Ph D. program abroad.

v) AFRA Project Co-Ordinators

Dr. K. A. Danso continued to serve as AFRA Project Co-ordinator for Non-Destructive Testing.

Prof. E.H.K. Akaho continued to serve as AFRA Project Co-ordinator for the Research Reactor Project.

3.9. EXPERT MISSIONS

Some members of staff went to various places on expert missions also some IAEA experts visited some of the departments and units of the Institute in the year 2001.

(a) Drs. A. Pietruszewski and T. Moriarty of the IAEA, Vienna conducted safeguards inspection of Ghana Research Reactor-1, 13 – 14 February, 2001.

(b) Prof. E.H.K. Akaho of NNRI was invited to give lectures on the Physics of Radioisotope Production at the IAEA Regional Training Course on Isotope Production, Cairo, Egypt, 12 – 23 May, 2001.

(c) Dr. Tommie Victor of Department of Medical Biochemistry, University of Stellenbosch, South Africa visited the Chemistry Department, 2 – 12 October, 2001.

(d) Prof. A. Chatt of the Dalhousie University, Canada visited the Reactor Project, 18 – 30 November, 2001.

(e) Dr. P. Kregsammer an IAEA expert visited and repaired the X-ray generator unit at the XRF laboratory towards the end of the year.

(f) An expert-team of two, was sent down from Hungary by the IAEA to RTC to help us repair the Gamma Irradiation Facility which had broken down for about a year.

In August, 2001 another team came from South Africa to help in the formulation

of the strategic plan for the commercialization of the gamma irradiation facility among others.

(g) Mr. P. K. Obeng went on an IAEA Expert Mission to the Black Lion Hospital, Addis Ababa, Ethiopia, where he repaired the Gamma Camera and also trained the Local Staff.

3.10 PUBLICATIONS

The following papers were either published, accepted for publication (press) or submitted for publication:

(a) Published Papers

1. E. H. K. Akaho, S. A. Jonah, C. P. K. Dagadu, B. T. Maakuu, P. S. Adu, S. Anim-Sampong and A. W. K. Kyere - Geometrical effects on thermal neutron reflection of hydrogenous moderators using ^{241} Am-Be source, *Applied Radiation and Isotopes* **Vol.55, No. 5** (2001), 175 - 179.

2. E. H .K. Akaho, S. A. Jonah, C. P. K. Dagadu, B. T. Maakuu, S. Anim-Sampong and A. W. K. Kyere - Thermal neutron reflection method for measurement of total hydrogen contents in Ghanaian petroleum products, *Applied Radiation and Isotopes* **Vol.55, No.5** (2001), 13 - 18.

3. Y. Serfor-Armah, B. J. B. Nyarko, E. H. K. Akaho, A. W. K. Kyere, S. Osae, K. Oppong-Boachie and E. K. Osae - Activation analysis of some essential elements in five plant medicines used in Ghana, *J. Radioanal. & Nucl. Chem.* **Vol. 250, No.1** (2001), 173-176.

4. K.E. Danso, Y. Serfor-Armah, B.J.B. Nyarko, S. Osae, E.K. Osae, Determination of some mineral composition of cassava (Manihot esculenta Crantz) using INAA, *J. Radioanal. Nucl. Chem.* **Vol. 259 (1),** (2001), 139 – 141.

5. M. Boadu. E. K. Osae, A. A. Golow, Y. Serfor-Armah and B. J. B. Nyarko - Determination of Arsenic in water, ore and tailings in some water bodies at Konongo in the Ashanti region of Ghana and its surrounding towns and villages by INAA, *J. Radioanl. Nucl. Chem.* **240 (3)** (2001), 581 – 585.

b. Accepted Papers in Press

1. E. H. K. Akaho and B. T. Maakuu - Simulation of reactivity transients in a Miniature neutron Source Reactor core, *Nuclear Engineering and Design.*

2. Y. Serfor-Armah, B.J.B. Nyarko, J. Holzbecher, E.H.K. Akaho, E.K. Osae, A. Chatt Epithermal INAA in conjunction with Compton suppression spectrometry for the determination of iodine in various food samples, *J. Radioanal. & Nucl. Chem.*

3. B.J.B. Nyarko, Y. Serfor-Armah, J. Holzbecher, E.H.K. Akaho, E.K. Osae, A. Chatt, Epithermal INAA for the determination of gold and arsenic in Ghanaian gold tailings using conventional and anti-coincidence counting systems, *J. Radioanal. & Nucl. Chem.*

4. E. H. K. Akaho, S. A. Jonah, C. P. K. Dagadu, B. T. Maakuu, S. Anim-Sampong and A. W. K. Kyere - Analysis of total hydrogen contents in edible oils from oil palm tree using thermal neutron moderation method, *J. Applied Sc. & Tech.*

5. Y. Serfor-Armah, B. J. B. Nyarko, E. H. K. Akaho, A. W. K. Kyere, S. Osae and K. Oppong-Boachie - Multi-elemental analysis of some traditional

plant medicines used in Ghana, *J. Trace and Microprobe Techniques.*

6. P. O. Yeboah - Trends and Advances in Pesticide Residue Analysis, *J.A.S.T.*

7. P. O. Yeboah, S. Lowor and C. K. Akpabli - Determination of Pesticides in Thin Layer Chromatography, *J.A.S.T.*

8. P. O. Yeboah, S. Lowor and C. K. Akpabli - Thin layer Chromato-graphic method for screening Herbicide Residues, *J.A.S.T.*

9. P. O. Yeboah, S. Lowor, and C. K. Akpabli - Thin layer Chromato-graphic Rf and RRf values of Toxicologically significant pesticides on Standard Systems, *J.A.S.T.*

10. P. O. Yeboah, S. Lowor and C.K. Akpabli - Physico-chemical conditions for detection and determination of pesticides using TLC, *J.A.S.T.*

11. S. A. Dogbe - Effects of chemical sensitizers on gamma radiation processing of natural rubber latex produced in Ghana, *J.A.S.T.*, **5 (1&2), 2000.**

12. F. G. Ofosu, S Akoto Bamford and I. J. K Aboh - The Influence of Si (Li) detector Characteristics on the accuracy in X-ray analysis using QXAS package. *Journal of Ghana Sci. Asso.* **Vol 2, No 1, (2001).**

c) Submitted Manuscripts

1. E. H. K. Akaho, B. J. B. Nyarko, Y. Serfor-Armah, S. Osae, S. Anim-Sampong, B. T. Maakuu and K. Ahmad - Determination of neutron spectrum parameters of GHARR-1 Inner site using k_0 standardization NAA method (*J. Applied Sc. & Tech.)*

2. E. H. K. Akaho, B. J. B. Nyarko, Y. Serfor-Armah, S. Anim-Sampong and B. T. Maakuu - Determination of 24 elements in clays consumed in Ghana (*Ghana J. of Chem.*)

3. B. J. B. Nyarko, E. H. K. Akaho, Y. Serfor-Armah, S. Osae, S. Anim-Sampong and B. T. Maakuu - Validation of k_0-standardized NAA method for GHARR-1 inner Irradiation site (*Analyst*)

4. E. H. K. Akaho, S. A. Jonah, B. J. B. Nyarko, Y. Serfor-Armah, and A. W. K. Kyere - Simultaneous use of neutron transmission and reflection techniques for the classification of crude oil samples (*Applied Radiation and Isotopes)*

5. R. Acharya, E. H. K. Akaho, A. Chatt - Determination of Neutron Flux Parameters of Dalhouise SLOW-POKE-2 reactor k_0 NAA using Hogdahl Convention and Modified Westcott-formalism (*Journal of Radioanalytical & Nuclear Chemistry*)

6. C. T. Beni, B. A. M. Bandowe, B. T. Maakuu and E. H. K. Akaho - Screening of some Commonly used skin-lightening creams and soaps: A case study in Ghana (*J. Ghana Sc. Association).*

7. E. H. K. Akaho, R. Acharya, B. J. B. Nyarko and A. Chatt - A method for the calculation of modified spectral index for k_0-NAA using three different conventions applied to pure/ideal "1/v" (n/γ) reactions (*Nucl. Instr. & Methods*)

8. E. H. K. Akaho and B. J. B. Nyarko - Characterization of neutron spectra for irradiation Sites of Ghana Research Reactor-1 for k_0-NAA method using Westcott-formalism (*Applied Radiation & Isotopes)*

9. E. H. K. Akaho, B. J. B. Nyarko, Y. Serfor-Armah, S. Osae and B. T. Maakuu - Application of two standardization methods of neutron activation analysis technique for multi-elemental analysis of a tropical honey. (*Journal of Ghana Science Association*)

d) Conference Papers

1. P. S. Adu, E. H. K. Akaho, B.T. Maakuu and C.P.K. Dagadu, A methodology in the Production of Br-82 from Radiotracer Applica-tions, *Proc. of the Second AFRA Regional Conference on Research Reactors for Socio-economic Development*, 15 – 16 March, Pretoria, South Africa (in press)

2. P. S. Adu and E. H. K. Akaho, B. T. Maakuu and C. P. K. Dagadu, Determination of Anomalies in Leaching Tanks of a Ghanaian Gold Mine, *Proc. of the Second AFRA Regional Conference on Research Reactors for Socio-economic Development*, 15 – 16 March, Pretoria, South Africa (in press).

3. E. K. Nani, A. W. K. Kyere, G. K. Tetteh and E. K. Addison, Transit Dose Calculations around straight Catheters in HDR Brachytherapy.

4. E. K. Nani, Optimisation Methods in Breast Cancer Treatment – The Breast Jig. Paper presented at First congress of the African Oncology Group.

5. S. Akoto Bamford, I. J. K. Aboh, F. G. Ofosu and Catherine Amoateng - Analysis of Airborne Particulate Matter (APM) associated with Combustion Processes. *Proc. of Workshop on "Monitoring of Air Pollution due to combustion Processes"*

3.11 CONSTRAINTS/PROBLEMS

The Problems of the Institute have been many. In order to fully justify the huge financial investment in the acquisition of equipment, the following constraints and problems are identified and recommended for the attention of policy makers:

1. The major one being the lack of funding for research.

2. The Mechanical Engineering Section needs a computer for computer-aided design and draughting. Drawing boards and drawing instruments are also needed. In addition, qualified draughtsman, machinists and a welder should be employed.

3. The lack of functioning national NDT Society in Ghana makes it difficult for the establishment of a national qualification and certification body.

4. In order to enhance the commercial activities within the Departments and Sections of the Institute, there is the need for seed money.

5. The lack of Business/Marketing Manager to assist in the commercial activities is a serious set-back to commercialization. It is practically not possible for the scientist/engineer involved in research, production of items or rendering analytical services to find time to undertake market survey for finished goods. It is suggested that the Commission undertakes serious Market Development through adverts, market research to enhance its commercialization program.

6. The Department of Chemistry has no General Laboratory where simple solutions can be prepared. Failure by the Commission to provide the requisite

basic infrastructure and functional equipment such as benches, Fume hoods, tables and chairs has prevented the Department from achieving its objectives.

7. With respect to rehabilitating the two GC equipment, efforts by Scientists even to employ funds from their Coordinated Research Contracts awarded by the IAEA are frustrated by the Commission. This has resulted in the equipment standing idle since 1999.

8. The ratio of Technicians to Scientists in the Chemistry Department stands at 1:6. The situation shall be made worse by the fact that one of the two Chief Technicians shall go on retirement in 2002. Efforts must be made to engage technicians to rectify the situation.

9. Lack of vehicles for sample collection at the various project sites.

10. The broken down Liquid Nitrogen Plant needs to be repaired. This is a vital equipment for the provision of liquid nitrogen for the radiation detectors used by both the XRF and NAA Laboratories without which detection cannot be optimized.

11. The major problem facing DENIC is that, the Institutes and Departments under the Commission do not pay for the services rendered them, as a result no revenue is generated and most of the Electronic parts are depleted and cannot be replenished.

12. The water leakage at DENIC has worsened. The whole place becomes flooded whenever it rains. If nothing is done now, some Air conditioners and other sensitive electronic equipment may catch fire as a result of water pouring on them during rainfall.

* Though some equipment were received at DENIC to enhance our work output, lack of funds to purchase research materials slowed down our work. For instance, the work on thermolumine-scent properties of local clays delayed in the course of the year due to lack of funds and the break down of the TLD readout instrument at the RPB. It is therefore recommended that research funds are made available for the purchase of inputs for research.

3.12 PROJECTIONS

1. On-going research activities in reactor physics, shielding and thermal-hydraulics will continue. Specific areas of interest are as follows:

   (a) Monte Carlo Simulation of the Highly Enriched Uranium-Fueled GHARR-1 using MNCP 4A
   (b) Calculations for Core conversion from HEU to LEU fuel
   (c) Optimized Conditions for the Operation of a Low Power Reactor MNSR for Production of Therapeutic Radio-pharmaceuticals for Endoradiotherapy

2. Under AFRA program for Research Reactor Utilization for Socio-Economic Development for Africa, the following **research contracts** involving the use of the research reactor were proposed for financial support from the International Atomic Energy Agency:

(a) Seaweeds as bioindicators for monitoring toxic element pollutants in the marine ecosystem – Chief Investigator, Mr Y. Serfor-Armah
(b) Determination of toxic elements in mining waste waters nearby rivers and vegetation - Chief Investigator, Mr. B. J. B. Nyarko
(c) Multipurpose geochemical mapping of Ghana - Chief Investigator, Dr. S. Osae

(d) Production of radiotracers Br-82 and Ar-41 for application in petro-chemical industry - Chief Investigator. Ms. P.S. Adu

3. In collaboration with the Geological Survey Department of Ghana, a project on "Geochemical comparison of laterites overlying different types of bedrock" will be undertaken using the reactor for neutron activation analysis technique.

4. For material science research, the following topics will be investigated:

(a) Using ultrasonic pulse echo velocity measurements to determine the mechanical properties of engineering materials. This project will benefit manufacturers that will want to know the mechanical properties of materials intended to be used in the manufacture of products to ensure safety and durability.

(b) Non-destructive testing (NDT) of concrete and other composite materials using 300 KVP directional X-ray machine and Iridium-192 gamma source. The results of this project will be of great benefit to Accra Metropolitan Authority, Estate Developers, Ghana Highway Authority and structural engineers who are interested in the quality of metallic components in concrete structures.

5. The NDT Section has submitted an application for Technical Co-operation Agreement to IAEA for the establishment of a System of Training and Certification for NDT Personnel in accordance with ISO9712 including Concrete testing Capability. The training will qualify personnel to Level II to cover radiographic, ultrasonic, magnetic particle and liquid penetrant testing methods. The Section intends to include pressure test in addition to the testing capabilities in the near future.

6. The current situation in the Department of Chemistry is frustrating for scientists, technicians and the administrative supporting staff. Since its re-location to the new building, the Commission has failed to provide the necessary infrastructure and get the broken-down equipment rehabilitated to enable research to be undertaken. The Pesticides Research Group, for instance, has been relying on facilities at the Ecological Laboratory of the University of Ghana, and the Laboratory of the Water Research Institute of the CSIR for their work. In the absence of commitment by the Commission, the scientists at the Department are making themselves useful by helping with teaching in the Universities of Ghana.

7. The Department of Physics is looking forward to the installation of a liquid nitrogen plant to be funded either by the IAEA or from the Commission's resources. Full-scale implementation of soil mapping and environmental impact assessment programs and the provision of better methods of dose calculation at the radiotherapy unit.

8. In addition to continuing the existing maintenance and research programs, DENIC intends to run the following training courses and maintenance service to generate income for the Centre.

- Upgrading Computer literacy of Scientists and Administrative staff of GAEC.

- Microprocessors and their interfacing to Sensors.

- DENIC intends to extend its services to the manufacturing industry specifically to repair their microprocessor-based injection machines, which their own technicians are not capable of handing.

9. The gamma irradiation facility has been identified by GAEC to be commercialized to generate revenue to support research at the Commission. To achieve this the Commission intends to look for private sector participation to upgrade the existing facility. It is envisaged that the upgrading would also allow research into other applications where high dose rates are a prerequisite.

Despite these problems modest results were achieved on all fronts with papers either in publication or read at various conferences on both the local and international scene (see 3.10).

3.13 STAFF LIST

No.	NAME	QUALIFICATION	POSITION
	DIRECTORATE		
1.	Prof. A.W.K. Kyere	Ph.D	Director
2.	Mr. Felix Adeku	BSc., MBA	Sen. Admin. Officer
3.	Mr. I.C. Addo-Ayesu	Dip. (Gen. Edu.)	Sen. Admin. Assistant
4.	Ms. Justina Gli	Govt. Sec. Cert. And NVTI	Sen. Clerk
5.	Ms. Esther Tetteh-Mensah	Govt. Sec. Cert. And NVTI	Clerk Grade I
6.	Miss Judith T. Addy	GCE O Level, NACVET	Clerk Grade III (Temp.)
7.	Mr. Seth Nyarko	MSLC	Dept. Assist. Gd.I
	NUCLEAR ENGINEERING & MATERIAL SCIENCE		
8.	Prof. E. H. K. Akaho	BSc (Eng), MSc, PhD (Nuc. Eng.)	Prin. Sc. Officer (Head)
9.	Dr. H. O. Boadu	BSc, MSc, PhD (Nuc. Eng)	Sen. Sc. Officer
10.	Dr. K. A. Danso	BSc. MSc, PhD,PG Dip. (Comp.Sc.)	Sen. Sc. Officer
11.	Mr. M. S. Mahama	BSc(Eng), MSc(Eng)MGhInstP	Scientific Officer
12.	Mr. S. Anim-Sampong	BSc., Mphil (Physics), M GhInstP	Scientific Officer
13.	Ms. P. S. Adu	MSc. (Chem Eng.)	Scientific Officer
14.	Mr. B. T. Maakuu	BSc, M Phil, M GhInstp	Scientific Officer
15.	Mr. C. P. K. Dagadu	MSc. (Mech Eng)	Scientific Officer
16.	*Mr. D.N.A. Dodoo-Amoo	BSc., MSc (Physics)	Scientific Officer
17.	Mr. J. K. Gbadago,	BSc., PGDip(Health Phy), M.Phil	Scientific Officer
18.	Mr. B. B. T. Quarcoo	City &Guilds Part III (Plant Eng.)	Chief Tech (Mech.)
19.	Mr. E. Amanor	Dip. Lab Tech.	Chief Technician
20.	Mr. G. S. Adadevoh	City & Guilds Adv. Ref. Tech.	Chief Technician
21.	Mr. Daniel Foli	City & Guilds Part II in Welding	Principal Technician
22.	Mr. E. O. Amponsah-Abu	FTC-Elec Eng. Tech.	Principal Technician
23.	Mr. A. G. Ampong	HND Elect./Electronic	Senior Technician
24.	Mr. N. S. Opata	Cert. Lab. Technician	Senior Technician
25.	Mr. R. E. Quagraine	Dip. Mineral Technology	Senior Technician
26.	Mr. E. Amoakohene	H.N.D	Senior Technician
27.	Mr. M. Nyarko	N.C.C	Senior Technician
28.	Mr. E. A. Awuku	N.C.C	Senior Technician
29.	Mr. N. Asare	NVTI Gd. I	Senior Foreman
30.	Mr. P. Tawiah	H.N.D	Technician
31.	Mr. K. Kumah	H.N.D	Asst. Technician
32	Mr. A. S. H. Alex Kpodo	NCC	Foreman
32.	Mr. G. A. Patterson	NCC	Foreman
33.	Mr. H. E. Dinku	NVTI Grade I	Artisan
34.	Mr. S. Akotia	City & Guilds Inter Refrigeration	Tech. Asst. Gd. I
35.	Mr. S. T. Osakunor	MSLC	Tech. Asst. Gd. II
36	Ms. Theresa Osei Bonsu	GCE A Level	Steno.
37.	Miss. M. Ehumah	SSCE, NACVET	Temp. Typist
38.	Mr. V. Salifu	MSLC	Dept. Asst.
39.	David Ametepey (Deceased)	MSLC	Dept. Asst. II

	CHEMISTRY DEPARTMENT		
40.	Prof. J. H. Ephraim	Ph.D (Chem.)	Ch. Sc. Officer (Head)
41.	Dr. P..O. Yeboah	Ph.D (Biochemistry)	Senior Scientific Officer
42.	Mr. C. B. J. Semanhyia	MSc. (Chem.)	Senior Scientific Officer
43.	Dr. I. K. Wilson	Ph.D (Radio-Pharmacy)	Scientific Officer
44.	Mr. K. Ahmad	MSc. (Chem.)	Scientific Officer
45.	Mr. E. A. Aryeetey	MSc (Biochemistry)	Scientific Officer
46.	Mr. S. A. Dogbe	BSc, MSc. (Chem.)	Scientific Officer
47.	Mr. B. K. Osafo	MSc. (Chem. Eng)	Scientific Officer
48.	Mr. O. K. Gyamfi	M.Phil. (Chem.)	Scientific Officer
49.	Mr. Y. Serfor-Armah	M.Phil (Chem)	Scientific Officer
50.	Mr. D. G. Achel	M.Phil (Biochem)	Scientific Officer
51.	Mrs. P. T. Damptey	BSc. (Chem)	Scientific Officer
52.	Mr. S. Afful	BSc. (Chem)	Scientific Officer
53.	Mr. C. Debrah	BSc. M.Phil	Asst. Scientific Officer
54.	Ms. J. B. Armah	City & Guilds Adv. Cert.	Chief Technician
55.	Mr. B. Q. Modzinuh	Higher Dip Anal Chemistry MISCT	Chief Technician
56.	Mr. S. K. Debrah	MSLC	Senior Technician
57.	Mr. J. K. Prah	Dip. Glassblowing	Principal Technician
58.	Ms. M. A. Wayem	Stenographer Grade II	Administrative Assistant
59.	Mr. A. T. O. Nartey	O Level	Senior Clerk
	PHYSICS DEPARTMENT		
60.	Mr. O. C. Oppon	BSc. DU	Senior Sc. Officer (Head)
61.	Mr. I. J. K. Aboh	BSc, M.Phil	Senior Sc. Officer
62.	Mr. F. G. Ofosu	BSc, M.Phil	Scientific Officer
63.	*Mr. S. Akoto Bamford	BSc, M.Phil	Senior Scientific Officer
64.	Mr. B. J. B. Nyarko	BSc, MSc	Senior Sc. Officer
65.	Dr. Shiloh Osae	BSc. MSc. PhD.	Senior Sc. Officer
66.	Mr. H. M. Aniagyei	Dip Eng. MSc	Senior Sc. Officer
67.	Mr. Theophilus Sackey	BSc, MSc	Scientific Officer
68.	Mr. E. K. Nani	BSc. Mphil	Scientific Officer
69.	Mr. J. K. Acquah	Sc. Lab. Tech.	Principal Technician
70.	Mr. F. B. Johnson	Sc. Lab. Tech.	Principal Technician
71.	Mr. F. B. Awotwe Pratt	BSc, MSc	Scientific Officer
72.	Ms Hannah Nkrumah	Steno. Gd. II	Senior Clerk
73.	Mr. Bismark Assiamah	GCE O Level	Dep. Assistant Gd.III
	DENIC		
74.	Mr. P.K. Obeng	MSc, (Physics)	Snr. Sc. Officer (Head)
75.	Mr. P.K. Afriyie	BSc, MSc Digital Electronics	Scientific Officer
76.	Mr. Ernest Boadu	BSc, MPhil (Physics)	Assist. Scientific Officer
77.	Mr. Richard Asare	A Level, Dip. (IT)	Assistant Technician
78.	Mr. A. L. Okang	City & Guilds III	Chief Technician
79.	Mr. Emmanuel Mornoh	Elec. Tech. Part. III	Technician
80.	Mr. Sarpei Addy	NVTI Cert.	Technical Assistant II
81	Mr. R. Osei-Owusu	HND	Technician

82	Mr. J. A. K. Nsorh	Telecom & Electronic II	Technician
83.	Mr. Samuel Akigoh	GCE O Level	Dept. Assistant Gd.II
84.	Ms. Janet Kyeremanteng	MSLC	Senior Catering Assistant
85.	Mr. Moses Atandzi	MSLC	Electronics Apprentice
	RTC		
86.	Mr. Emi-Reynolds	BSc MSc	Snr Scien. Officer (Head)
87.	Mr. Isaac Ennison	BSc MSc	Scientific Officer
88.	*Mr. G. K. Banini	MPhil	Scientific Officer
89.	Mr. J. E. F. K. Ansah	City & Guilds Advanced	Chief Technician
90	Mr. M. Ofori-Appiah	HND, MIST. Higher Dip.	Chief Technician
91.	Mr. E. A. Quarcoo	BSc (HONS) Biology	Assist. Scientific Officer
92.	Mr. S. N. Y. Annan	HND Electronics	Technician
93	Ms. Beatrice Amoah	SSCE, NACVET	Typist Gd. II
94.	Mr. Jacob Arthur	MSLC/NVTI	Labourer
95	Mr. Fraser Oware	MSLC	Labourer

* On study Leave abroad / Leave of absence

SECTION FOUR

4.0 RADIATION PROTECTION BOARD (RPB)

4.1. INTRODUCTION

The provisions of PNDC Law 308 and further regulations LI 1559 of 1993 have mandated the Radiation Protection Board (RPB) to carry out the following activities:

(i) Authorize practices and the use of radiation sources within practices;

(ii) Conduct inspections for the purposes of issuance of authorization as well as regular inspection to ensure compliance with regulatory require-ments; and

(iii) Promote human resources development in radiation safety by promoting training of regulatory staff and organizing training courses for registrants and/or licensees.

4.2 VISION AND MISSION

4.2.1 Vision

To authorize, inspect and control all activities and practices involving radiation sources, ionizing radiation, radioactive materials and x-rays used in Ghana.

To commercialize activities and expertise for the socio-economic development of Ghana.

4.2.2 Mission

To ensure the protection of the Ghanaian population and in particular end-users of x-rays, radiation sources and radioactive materials from the harmful effects of ionizing radiation sources used in medicine, industry and research and teaching.

4.3. PERSONNEL

The staff at post during the year was made up of the following:

Position	Number at Post
Director	**1**
Scientific Staff	11
Technical staff	5
Administrative staff	7
Total	**24**

MAJOR RESEARCH FACILITIES

Facilities	Technologies/Expertise
1. Harshaw TLD 6600 Reader and Accessories	Personal and Environmental Monitoring Dosimetry
2. Gamma Spectrometry System and Accessories	Environmental and Radionuclide Contamination Assessment
3. Safety Assessment and Quality Control Equipment	Radiation Safety Assessment and Quality control measurements of diagnostic Medical x-ray facilities
4. Secondary Standards Dosimetry Laboratory	Calibration of Radiation Measuring Instruments
Training Facilities; Project, Video Films, Overhead projector, Training Materials	Basic and Specialized Training in Radiation and Waste Safety
6. Facilities for Regulatory Control Programme	Authorization, Inspection and Enforcement Procedures

4.5. RESEARCH ACTIVITIES

The following are on-going research projects being carried out at the RPB :

a) Occupational Radiological Exposure in the Mining Industry

Investigators: E. O. Darko, J. Yeboah and Mary Boadu

The primary objective of this project is to study the occupational exposure contribution and impact due to technologically enhanced radiation exposure in selected mining industries in Ghana starting with Ashanti Goldfields Limited.

(b) Studies on the Terrestrial Gamma Radiation in and around the Metropolitan area of Accra

Investigators: J. Yeboah, Mary Boadu and E. O. Darko.

Samples from different locations and geological formation have been taken and analysed for concentrations of naturally occurring radionuclides. The first phase of the project has been completed. A summary of the report has been published in the Journal of Radioanalytical and Nuclear Chemistry, Hungary.

(c) Studies on the optimization of patient dose in Radiation Therapy

Investigators: S. D. Asiamah, C. Schandorf, K. Nani, T. Sackey.

Patients undergoing selected radiation therapy procedures using Co-60 gamma rays have been assessed. Dose distribution to sensitive organs has been analyzed in relation to treatment planning procedures. Methods for minimizing patient doses outside the target volume are being pursued to ensure optimum safety of patients.

4.6. RADIATION AND WASTE SAFETY SERVICES

4.6.1 Food and Environmental Monitoring

For public exposure control, food samples and industrial raw materials imported into the country are analyzed for caesium contamination at the RPB laboratory. The Environmental Protection Agency (EPA), Customs Excise and Preventive Service

(CEPS) and the Ghana Standards Board (GSB) perform the sampling of these items at the ports of entry. Two hundred and sixty eight six (268) samples made up of milk powder and milk products (241), beef (4), poultry (11) and miscellaneous item (12). were measured and certificates issued. There was no significant caesium level detected in the samples measured.

4.6.2 Personal Monitoring

Personal Monitoring Service catered for 975 Personnel made up of 530 (54.4%) for medical x-ray diagnosis, 128 (13.1%) for research and teaching, 233 (22.9%) for industry, 81 (8.3%) for radiotherapy and nuclear medicine, and 13 (1.3%) for x-ray technical division. In all 163 institutions were monitored.

4.6.3 Dosimetry

Two (2) survey meters were calibrated at the secondary Standards Dosimetry Laboratory (SSDL) of RPB. The Abosso Goldfields at Damang in the Western Region and the Radiotherapy Centre at the Korle Bu Teaching Hospital are using the survey meters. Survey meters being used at Reactor Centre, Gamma Irradiator and RPB were also calibrated.

The Harshaw TLD 6600 Reader was used for the evaluation of Hp (0.07) and Hp (10) using ISO 4037 reference radiation generated by the Philips MG 324 x-ray system and accessories and the 37 TBq Cs-137 panoramic irradiator.

The SSDL undertook two (2) IAEA/WHO postal quality audit programmes during the year, one at therapy level and one at protection level. The performance at both therapy and protection levels were very good, within 5% of the IAEA certified value.

4.7. *HUMAN RESOURCE DEVELOPMENT*

4.7.1 Training/Seminar/Workshop/Conferences

(a) Training/Seminar/Workshop/Conferences attended by RPB Staff

No.	Name of Staff	Title of Training	Venue	Date
1.	Augustine Faanu	MSc. Programme in Environmental science	Nothingham University, U.K	25 Sept. 2000-25 Sept 2001
2.	*Clement Oppong-Adu*	*Regional Postgraduate program* in Radiation Protection and Safety of Radiation Sources	*Johannesburg*, South Africa	*30 July* -- 30 Nov. 2001
3.	Mrs. Naadu Ansong	MSc.in Environmental Studies	Freiburg, Germany	Oct. 2001 - Present
4.	C. Schandorf and J. O. Ankrah (NADMO)	IAEA Regional Workshop on Strengthening National Capabilities for response to Radiological Emergencies	Vienna, Austria	26-30 Nov. 2001
5	C. Schandorf and N. Asamany	First African Workshop on the Establishment of a legal Framework for Radiation Protection and Waste Safety	Addis Ababa, Ethiopia	23-31 April 2001
6	C. Schandorf	IAEA Conference on Security of materials	Stockholm, Sweden	7-11 May 2001
7.	J. K. Amoako	Workshop on Proposal Writing and Research Methodology	ISSER , Legon	21 June-29June 2001
8.	J. K. Amoako	Edward Bouchet Worshop on Differential Equations	Centre for Mathematical Sciences, GAEC	9-20 July 2001,
9.	C. Schandorf	TCM/Workshop on the Safety of Radiation Sources and Security of Radioactive Materials	Rabat, Morocco	16-20 July 2001
10.	Ben Doe Gbekor	Workshop on Distributed Laboratory Instrumentation System	ICTP, Trieste Italy	26 Nov.- 26 Dec. 2001
11	E. O. Darko	Third Regional College on Modeling, Simulation and Optimization	Centre for Mathematical Sciences, GAEC, Kwabenya	8 – 18 May 2001

(b) IAEA Regional Training courses organized by RPB

The Radiation Protection Board on behalf of the International Atomic Energy Agency organized one Regional Training Course on the Organization and Implementation of a National Regulatory Programme for the Control of Radiation Sources from 6-17 August, 2001. Twenty-four participants from thirteen African countries were involved.

4.7.2 IAEA Fellowship Training Organized by RPB

RPB organized an IAEA fellowship training program for three fellows from three African countries:

No.	Name of Fellow	Nationality	Type/Areas of Training	Venue/Period
1	**Adeyemi Adefemi** Oyedipe	Nigerian	Safety Assessment and Personal Dosimetry	Accra, Ghana 15 Jan – 14 April 2001
2	Solomon Amos Kamya	Uganda	Safety Assessment and Personal Dosimetry	Accra, Ghana 15 Jan – 14 April 2001
3	Ralinirima Dina Randriantsizafy	Madagasca	Safety Assessment and Regulatory Authorization	Accra, Ghana 15 Jan – 14 April 2001

4.7.3 National Training Courses

The following National Training courses were organized by the RPB

No.	Institution	Title of Training	Venue	Date
1.	Abosso Goldfields Ltd.	**Safe Use of Radiation** Sources	Damang, W/R	5 - 9 Nov.2001
2.	Ashanti Goldfields. Bibiani Ltd.	**Safe Use of Radiation** Sources	Bibiani, W/R	12 –16 March 2001
3.	Gateway Services Ltd.	Occupational Radiation Safety and Emergency Response Plan	Tema, GAR	7 – 8 May 2001
4.	Ministry of Health for Radiographers in the Ashanti Region	Safety Aspects of the Medical uses of X-rays	Kumasi, ASR	5 – 7 Sept. 2001

4.8. EXPERT MISSIONS

4.8.1 IAEA Expert

Dr. Jozef Palfalvi, an IAEA expert visited the Board from 3 – 7 December 2001 under RAF/9/029-011 on the Development of Technical capabilities for sustainable Radiation and Waste Safety-Upgrading Radiation Monitoring and Protection Capability. The purpose of his visit was to help RPB repair and update the broken down TLD reader 2000.

4.8.2 Scientific Visit

Mr. Josephus Jibao Kongo from Sierra Leone was on scientific visit to RPB from 5 – 8 November, 2001. The program for his visit was on the Implementation of TC related projects and review of some radiation protection regulatory framework including legislation and regulation.

4.9 PUBLICATIONS

4.9.1 Refereed Papers

The following papers were published or submitted for publication in refereed journals:

(a) J. Yeboah, M. Boadu and E. O. Darko. "Natural radioactivity content of soil and rocks within the Greater Accra Region of Ghana". Accepted for publication in the *Journal of Radio Analytical and Nuclear Chemistry*, **Vol. 249 No.3** (2001) 629-632, Hungary

Synopsis
Natural radioactivity in soil and rock samples from different geological structures in selected locations within the Greater Accra Region of Ghana has been studied using gamma-spectrometry. Results indicated that the major contributors to terrestrial background radiation is the natural radioactive series notably K-40, U-238 and Th-232. Estimated exposure rate at 1m above the soil surface ranged from 0-9 to 20.6 μR/h in soil and 0.6 to 17.8μR/h in rocks. Granite rocks at Dodowa contain higher level of the naturally occurring radioactive elements. The relatively low concentration round the Shai Hills may be due to the predominance of sand.

(b) J. K. Amoako, C. Schandorf and Naadu Ansong. **"Authorization for Safe Use of X-ray Scanner Technology in Ghana".** ***Journal of Applied Science and Technology*** **CSIR, Accra, Ghana. (Submitted)**

Synopsis
The method used for the assessment and personal monitoring results for one-year operation of the x-ray scanner used for the inspection of laden containers at the Tema Port are outlined in this paper.

Doses received by personnel have been compared with those of radiation workers in other institutions. The results indicate that despite the potential hazards posed by the scanner, adequate safety measures are in place to ensure the safety of the workers and members of the general public.

(c) D. F. Charles, A. Andam and C. Schandorf "Shielding properties of some Ghanaian Hardwoods" *Journal of Radiological Protection*, U.K. (Submitted)

Synopsis

The linear and mass attenuation coefficients have been estimated for four selected Ghanaian hardwood species namely: Kruma (*Klainedoxa gabonensis*), Potrodom (*Erythrophleum africanum*), Dahoma (*Piptadenia africana*) and Odum (*Milicia excelsa*), using a selection of eight x-ray qualities with tube voltages ranging from 60kV to 150kV generated by a Philips MG 324 constant potential x-ray generator. For Kruma of density 1050 kgm^{-3}, the mass attenuation coefficients range from 0.0160 ± 0.005 to 0.0558 ± 0.005 m^2kg^{-1}. For Potrodom of density 900 kgm^{-3}, mass attenuation coefficients range from 0.0172 ± 0.005 to 0.0457 ± 0.005. For Dahoma of density 700 kgm^{-3}, the mass attenuation coefficients range from 0.0152 ± 0.005 to 0.0442 ± 0.005 m^2kg^{-1}. For Odum of density, 650 kgm^{-3}, the mass attenuation coefficients range from 0.0138 ± 0.005 to 0.0485 ± 0.005 m^2kg^{-1}.

Conference Papers

1) C. Schandorf, J. K. Amoako, S. D. Asiamah, "Development of measures to deal with illicit trafficking of Nuclear Materials in Ghana". Proceedings of IAEA International Conference on Security of Materials, Stockholm, Sweden, 7 - 11 May, 2001.

2) C. Schandorf, E. O. Darko, J. Yeboah and S. D. Asiamah. "Enhancing the Technical and Administrative Capabilities for Safety and Security of Radiation Sources and Radioactive Materials" Proceedings of IAEA Technical Committee Meeting/Regional Workshop on the Safety of Radiation Sources and Security of Radioactive materials, Rabat, Morocco, 16 - 20 August, 2001.

3) S. D. Asiamah, C. Schandorf and I. K. Danso. "Status of Industrial Radiography Practice in Ghana." Proceedings of Fifth EAN workshop on Industrial Radiography: Improvement in Radiation Protection, Rome, Italy, 17-19 October, 2001.

4.10CONSTRAINTS/PROBLEMS

The main problems that militated against efficient and effective performance of work at the Institute include:

1. Inadequate support for regulatory activities and research work
2. Delay in releasing approved budget for research activities.
3. Inadequate resources available for the rehabilitation of the laundry room to be converted into officers and laboratory.
4. Frequent breakdown of sensitive equipment from power outrages.
5. Lack of adequate computing and Internet facilities

4.11 PROJECTIONS

The research work, regulatory inspections and authorizations, and Technical services are on-going activities at the RPB. It is hoped that these projects would be pursued to their conclusion with the needed support from the Board and the GAEC

4.12 Staff list

No.	Name of Staff	Qualification	Position
1	Prof. C. Schandorf	Ph.D., M.Sc. Physics	Principal Scientific Officer/Director
2	Mr. E. O. Darko	M. Phil, B.Sc. (Hons) Physics	Snr. Scientific Officer/ Head, Radiation & Waste Safety Dept.
3	Mr. J. Yeboah	M.Sc. (B.Sc. (Hons) Physics	Scientific Officer/ Ag. Head, Regulatory Control Dept.
4	Mr. S. D. Asiamah	M. Phil., B.Sc. (Hons) Physics	Scientific Officer
5	Mr. J. K. Amoako	M. Phil., B.Sc. (Hons) Physics, PG.D (Rad. Prot.)	Scientific Officer
6	Mr. E. K. Osei	M.Sc., B.Sc. (Hons) Physics	Scientific Officer
7	Mrs. Mary Boadu	M.Sc., B.Sc. (Hons) Chemistry	Scientific Officer
8	Mr. D. F. Charles	MSc..B.Sc. (Hons) Physics	Asst. Scientific Officer
9	Mr. C. Oppong-Adu	B.Sc. (Hons) Physics	Asst. Scientific Officer
10	Mr. A. R. Awudu	B.Sc. (Hons) Biology	Asst. Scientific Officer
11	Mrs. N. Ansong	B.Sc. (Hons) Physics	Asst. Scientific Officer
12	Mr. A. Faanu	B. Sc. (Hons) Chemistry	Asst. Scientific Officer
13	Rev. G. E. Akoto	Dip. Lab. Tech. Personnel Dosimetry	Chief Technician
14	Mr. L. A. N. Quaye	Sc. Tech. Cert.	Principal Technician
15	Mr. M. K. Obeng	Dip. Lab. Tech.	Senior Technician
16	Mr. G. D. Gbekor	Dip. Lab. Tech.	Senior Technician
17	Mr. L. O. A. Yeboah	Sc. Lab. Tech. Cert.	Senior Technician
18	Mrs. M. Martin-Nortey	M.BA., BA (Admin)	Administrative Officer
19	Mr. I. B. B. Basing	Dip. in Public Administration	Chief Admin. Asst.
20	Mrs. D. Dumoga	HND SEC/MGT	Snr. Admin. Asst.
21	Ms. D. Asamoah	NACVET Steno. Sec. Cert.	Administrative Asst.
22	Mrs. C. N. A. Torto	NVTI	Clerk Gd. 1
23	Mr. L. A. Darko	NVTI	Clerk Gd. 1
24	Mr. S. A. Agyei	G. C. E. 'O' Level Cert.	Clerk Gd. 2

SECTION FIVE

5. BIOTECHNOLOGY AND NUCLEAR AGRICULTURE RESEARCH INSTITUTE (BNARI)

5.1 INTRODUCTION

BNARI is a research, development and technology transfer institution with a focus on the use of biotechnology and nuclear science to address sustainable agriculture, health, and industrial needs of the country. It is the only Institute in Ghana that enjoys the comparative advantage in the utilization of both biotechnology and nuclear techniques in its services carried out through its three departments namely: Animal Science, Plant and Soil Science and Food Science and Radiation Processing. The Administrative set up of the Institute comprises a Directorate which co-ordinates and collates both the administrative and scientific inputs from the three departments. In each of the three departments is also located a detached registry which serves the specific needs of the particular department. Though the expected government budgetary support for research was not received, scientists carried out various research activities with support received from other sources.

5.2 VISION, MISSION AND STRATEGIC OBJECTIVES

5.2.1 Vision

To be the leading Institute in the applications of Biotechnology and Nuclear Science for agricultural research and development activities in Ghana through the pursuance, perfection and adoption of state-of-the-art technologies relevant to finding solutions to problems mitigating against accelerated development of the economy.

To be the Centre of Academic Excellence for the packaging and dissemination of technical information related to applications of Biotechnology and Nuclear Science in agriculture, while extending its facilities for training the youth.

5.2.2 Mission Statement

The Institute exists to explore the applications of biotechnology and nuclear science in research towards increased as well as sustainable agricultural production in support of national socio-economic development goals.

5.2.3 Strategic Objectives

The research thrust of the institute is focused on the following strategic objectives:-

- Crop improvement, production of planting materials and *in vitro* conservation.
- Improvement in Livestock Nutrition, Production and Health.
- Integrated Insect Pests/Vectors Management using biological and genetic methods and environmentally safe strategies.
- Prevention of post-harvest losses.
- Food preservation and Safety.
- Improvement in Soil Management Practices.
- Transfer of research technologies to farmers and industries.
- Strengthening industrial delivery capacity.
- Strengthening linkages with collaborating local and international agencies.
- Strengthening of human and material resources in biotechnology.

5.3 PERSONNEL

5.3.1 Nominal Roll

Staff strength of the institute as at 31st December 2001 was as follows:

Position	No. at Post
Director	1
Scientists	23
Technical Staff	**25**
Administrative Staff	12
Supporting Staff	9
TOTAL	**70**

5.3.2 Recruitment

Nine (9) people were employed in the Institute in their respective designations during the year under review:

Name **Designation**	**Date of Employment**
1. Mr. Eric Asare Assist. Scientific Officer (Temporary Appointment)	1st March
2. Mr. Samuel Timpo Assist. Scientific Officer (Socio-Economist)	1st March
3. Mr. Mawuli Torsu Production Assistant	8th May
4. Mr. Seth Asare-Bediako Production Assistant	8th May
5. Mr. Kennedy Tetteh Farm Hand	14th May
6. Mr. Stephen N. O. Lartey Farm Hand	15th May
7. Mr. Samuel Donkor Farm Hand	16th June
8. Mr. Edward Aglago Farm Hand	16th June
9. Mr. Abraham Tetteh Farm Hand	18th June

5.3.3 Dismissals/Transfers

NIL

5.3.4 Retirement

Mr. Kojo Gyapia Montford, a Senior Scientific Officer (Stored Products Entomologist) in the Department of Food Science and Radiation Processing, retired from the services of the Institute on 11th July, 2001.

5.3.5 Resignation

Mr. Prince Asiamah, a Farm Hand, resigned from the services of the Institute in May 2001. He was in the Department of Plant and Soil Sciences.

5.3.6 Promotions

The following four staff members were promoted on 1st January, 2001

Mr. Ernest Dinku
Principal Technician to Chief Technician

Mr. Tahiru Mahami
Technician to SeniorTechnician
Mr. Godfred Damnyag
Technician to SeniorTechnician

Ms. Comfort K. Mensah
Clerk/Typist II to Clerk/Typist I

5.4 MAJOR RESEARCH FACILITIES

The following are the main facilities used by scientists to carry out research during the year:-

i). Entomology Laboratory/Tsetse Insectary.

ii). Food Science Laboratory
iii). Microbiology Laboratory

iv). Plant Tissue Culture Laboratory.

v). Stored Products Laboratory.

vi). Ten-hectare arable land for field research

5.5 RESEARCH ACTIVITIES

5.5.1 DEPARTMENT OF PLANT AND SOIL SCIENCE

5.5.1.1 AGRONOMY AND CROP IMPROVEMENT

The Department of Plant and Soil Sciences engaged in the breeding of African yam bean, cowpea, cassava, cocoyam, plantain/banana, pineapple, cassava and yam through application of *in vitro* and nuclear techniques.

(a) Conservation and Improvement of the African yam bean, *Sphenostylis stenocarpa*)

Amoatey, H.M., Klu, G.Y.P, Bansa, D., Kumaga, F.K., Aboagye, I.M. Bennett-Lartey, S.O. & D.K. Gamedoagbao

Sponsorship: IAEA/AFRA
Funding: Minor equipment only

Background:
The African yam bean, *Sphenostylis stenocarpa* Hochst ex A. Rich is a small-holder's crop in Ghana. It has food qualities comparable to cowpea, lima bean and bambara groundnut. Besides, it produces underground tubers with higher protein content than any of sweet potato, yam or cassava. There is the danger of this legume disappearing from the hands of traditional farmers due to the popularity of the major legumes. The study is aimed at collection and conservation of available accessions of the African yam bean to prevent its total extinction as well as improvement of cultivation and utilization towards development and promotion as a major commercial pulse crop in Ghana.

Work done and Results:
In 1998, two field trips were undertaken to the northern part of the Volta Region (Nkwanta District) to collect germplasm for evaluation and characterization as a first step towards improvement of the crop. Seeds of seven accessions were collected.

During 1999, further field expeditions were made to the Nkwanta District and also the Ho-West District (in the middle belt of Volta Region). These trips yielded additional 17 accessions.
The 24 accessions were planted out in multi-locational field experiments between May and July at Gbadzeme (Ho-West District), Kpassa (Nkwanta District), Bunso (Plant Genetic Resources Centre; East Akim District) and Kwabenya (BNARI Farm; Amasaman District) for characterization and evaluation. The experiments were repeated at three locations in 2000. Also, based on a schedule drawn towards improvement of the crop using mutation breeding, one cultivar with desirable seed characteristics was selected for mutation induction.

Following a radiosensitivity test, two doses (150 Gy and 200 Gy) were used in inducing variability for selection towards early flowering and improved seed coat characteristics. M1 populations of 3000 seeds per dose were planted in the field from which M2 seeds were obtained. In 2001, the M2 population was planted out in the field for

evaluation alongside control material. Selection of putative mutants will be done in the M3 generation, which will be planted in 2002.

(b) Growth and Productivity Responses of Cowpea to Planting Densities and Sowing Dates on the Coastal Savanna Zone

D. K. Asare, S. Adiku and H. M. Amoatey

Sponsorship: Local
Funding: by BNARI through subvention

Background

Cowpea is a major crop grown extensively in the Coastal Savanna Zone. The crop is a protein source in foods and it improves nitrogen status of soils. As cowpea is usually grown under rain-fed conditions, there is the need to identify the best time to plant/sow and appropriate plant densities for optimizing yield levels.

The ***objectives*** of the study are:

(i) To evaluate sowing date and planting density interactions on the productivity of cowpea varieties.

(ii) To develop database for cowpea modelling studies.

Woke done and Results

An experiment was initiated in 2000 to investigate the responses of two varieties of *N.* cowpea to different planting densities and sowing dates on the Coastal Savanna Zone. The experiment was sited on-station at BNARI Experimental Farm. The experimental design was split-split plot design in three factors arranged in three replicates.

In 2001, the experiment was repeated using the same two varieties of cowpea, grown on-station at the BNARI Experiment Farm, during the major rainy season at three sowing dates and three plant population densities. Description of the factors is as follows:

COWPEA VARIETIES:
- Ayiyi (Elite, marketed by MOFA)
- Ayiyibor (Landrace, obtained from Kpeve market)

SOWING DATES:
- Early planting (1st week in May)
- Normal planting (mid-May)
- Late planting (last week in May)

POPULATION DENSITIES:
-1plant/hill, 2 plants/hill, and 3 plants/hill.

Measurements included date on which 50% flowering and crop maturity occurred, leaf area index, aerial biomass accumulated during the season, grain yield and soil moisture content at sowing, flowering and crop maturity.

Preliminary results indicate that Ayiyi flowered and matured earlier (about one week) than the landrace variety Ayiyibor. They also show that crop growth and grain yield declined for late planting. Processing and analysis of data collected are in progress.

(c) Developing Sustainable Fertilizer Recommendation for Cassava in the Coastal and Inland Transi-ional Agro-ecological Zones

Issaka (Soil Research Institute, Kwadaso-Kumasi) and D. K. Asare (BNARI).
Sponsorship: MOFA/RTIP
Funding: IFAD

Background

Prroject is a sub-set of the National Root and Tuber Improvement Programme co-ordinated by MOFA, which has an overall objective of enhancing cassava production and improving income levels of resource-poor cassava farmers. It is a Collaborative

Research between Soil Research Institute, Kwadaso-Kumasi and BNARI, Kwabenya. The focus is on the use of elite cassava varieties (Tekbankye, Afisiafi and Abasafita) and improved management practices.

Specific ***objectives*** are:

(i) to develop fertilizer response curve for three elite cassava varieties

(ii) to introduce farmers to promising cassava varieties

(iii) to introduce farmers to the use of fertilizers to enhance cassava production

Work done and Results

In 2000, on-station experiments were set up at Kpeve (V/R) and Asuansi (C/R) in which three cassava varieties (Abasafita, Afisiafi and Tekbankye) were grown under two farming systems and five nutrient levels. The experimental design was split-split plot in four replicates. The farming systems were the sole cassava crop and maize/cassava intercrop. The nutrient (NPK) levels were 0-0-0, 30-30-30, 60-60-60, 90-90-90 and 120-120-120 kg ha^{-1}.

Additionally, on-farm experiments involving farmers were set up at Kpeve and Asuansi and their surroundings. The three cassava varieties were grown under the sole cassava crop and maize/cassava intercrop and two nutrient (NPK) levels (0-0-0 and 60-60-60 kg ha^{-1}). The experimental design was incomplete block with each farmer representing one replicate. Measurements included crop establish-ment, growth rate at selected sites, yield, soil nutrient levels at sowing and crop (cassava) maturity.

The experiment was repeated in 2001 with 33 farmers involved in on-farm tests at Kpeve and 7 at Asuansi and their surroundings. Maize yield data from the on-station and on-farm experiments are being processed for analysis.

(d) Detection of DNA Polymorphism in Two Cassava Varieties using Inter-Simple Sequence Repeats (ISSR)

K. Owusu-Ayeh

Sponsorship: IAEA

Background:

Molecular techniques have been applied world-wide to accelerate plant breeding efforts. In the build up to establishing a fully operational Plant Biotechnology Laboratory in the Institute, it is desirable that researchers equip themselves with such useful techniques to enhance their work. The IAEA in collaboration with the FAO organized an Interregional Training Course aimed at enhancing knowledge and provide practical training on current molecular marker techniques and their use in evaluation and characterization of crop biodiversity, focusing on mutants to facilitate breeding programs.

Work done and Results

The opportunity offered by participation in this programme was utilized to attempt to distinguish between two varieties of cassava (Abasa fitaa and 408786) using molecular characterization methods.

DNA extraction from cassava leaves was done using the CTAB method. The polymerase chain reaction (PCR) was performed using a master mix provided by the host laboratories. The laboratory also supplied three primers that were used in the investigations. The use of the Inter Simple Sequence Repeat (ISSR) DNA polymorphism allowed the two cassava varieties to be distinguished successfully at the molecular level. The technique can be successfully applied in the laboratory in BNARI once the requisite equipment and reagents are available.

(e) Characterization and Improvement of Cocoyam through Mutagenesis.

E *Y. Danquah* (UG) Legon and *E. K. Asare* (BNARI), Kwabenya

Sponsorship: IAEA
Funding: Research Contract

Background:
Cocoyam is an important root crop in Ghana. It features extensively in the traditional, mixed farming system. The specialized roots called cormels as well as the leaves constitute important sources of food. The crop has received very little attention from researchers in the past leading to a situation whereby charac-teristics of local accessions important to the breeder are not known and these accessions are generally unimproved land-races.

The main objectives:

i. to characterize the genetic resources of cocoyam using morphological, agrono-mic and molecular markers.
ii. to breed for resistance to stem-rot disease through mutagenesis.

Work done and Results
In 1999, the cocoyam germplasm main-tained at Bunso and Fumesua were assembled at the University of Ghana and planted out in single rows of ten plants for each accession at the University Farm. Morphological characterization was done using standard descriptors recommended by the IBPGR. Also in 1999, a radio-sensitivity test was conducted to determine a useful irradiation dose for inducing mutations *in vitro* cultures of cocoyam. 10 Gy was selected following this test. Subsequently, shoot tips of cocoyam cultivar RAX were subjected to gamma irradiation at 10 Gy and cultured *in vitro* through 1999 – 2000.

In 2001 further shoot tips were procured, irradiated and cultured *in vitro* to generate a targeted 3000 plantlets for field evaluation with respect to resistance to stem rot. The plantlets shall be weaned in March 2002 prior to field transfer.

5.5.2 DEPARTMENT OF FOOD SCIENCE AND RADIATION PROCESSING

The Department of Food Science and Radiation Processing has three research programmes: Food Science and Nutrition; Radiation Processing; Food and Environmental Biotechnology.

5.5.2.1 FOOD SCIENCE AND NUTRITION PROGRAMME

The Food Science and Nutrition Programme investigates the physical, chemical, micro-biological, functional and nutritional properties as well as the sensory and shelf-life of food commodities. These studies provide the baseline data and justification for the application of irradiation to improve food quality and also complement the screening of some food crops by the plant breeders. It is important to note that the application of radiation processing is basically to meet a need that conventional processes are unable to address.

a. The Determination of the Hygienic Quality of Frozen Chicken in Cold Stores and Open Market.

Victoria Appiah, A. Adu-Gyamfi, and Stella Nkansah

Project status: This is the first phase of the project on the irradiation of poultry.

Justification:
The feeding and handling of the animal before slaughter, handling during slaughter, processing and marketing, influence the hygienic quality of meat and meat products. Meats are the primary source of many food-borne diseases. There is a lot of underreporting of cases of food borne diseases especially in developing countries like Ghana so reliable data is unavailable. However, there are instances where mouldy grains not fit for human consumption are fed to animals and the animals are kept under

less hygienic conditions compared to what pertains in the developed countries. Consequently, there is the need to investigate and ascertain the microbiological quality and safety of meat, poultry and their products.

Cooking foods thoroughly has been one of the effective ways of preventing food borne diseases traditionally. Although poultry and red meat are usually consumed after exposure to heat treatment sufficient to destroy vegetative cells, bacterial spores may survive. In addition, post process contamination of the cooked products originating from raw meat can occur and render them potentially unsafe. It is imperative that effective measures are taken to ensure the microbiological safety of cooked poultry and red meats.

Objectives

i. To determine the microbiological quality of frozen chicken.
ii. To identify the micro-organisms present in frozen chicken.
iii. To determine the efficacy of cooking procedures and post-process handling on the microbiological quality and safety of cooked poultry.
iv. To use gamma radiation, if necessary to improve the hygienic quality and safety of poultry as well as extend shelf life.

Work done and Results

Frozen chicken parts were purchased from cold stores and the open market in Dome for the study. Total viable counts of microorganisms were determined on 5 gram pieces. Results so far show the presence of faecal coliforms in the samples from the cold store as well as from the open market (Table 1). There is therefore the need to improve the hygienic quality of the product.

Table 1 - Microbiological Counts (cfu/g) on Frozen Chicken

	Market	*Cold Store*
Total viable counts	1.8×10^7	7.6×10^5
Faecal coliforms	1.7×10^4	7.5×10^2

Total viable count and faecal coliforms on the open market samples were higher than the counts on the samples from cold stores. Further characterization of the microbes isolated from the poultry is in progress.

Beneficiaries

Successful completion of this project will benefit the poultry industry and the consuming public. If irradiation of poultry is introduced it will improve the hygienic quality and reduce food poisoning caused by contaminated poultry.

b) Microbiological Quality of some Ready-to-Eat Complete Meals sold in Accra.

Josephine Nketsia-Tabiri and Abraham Adu-Gyamfi

Status: On-going (forms part of IAEA Project 10)

Justification:

Ready-to-eat complete meals have become an important and well-established sector of the food industry in Ghana due to their convenience and changing social trends of the population. The shelf-life of such prepared meals is limited to a few hours due to post-process contamination with both spoilage and pathogenic micro-organisms. This concern was confirmed by a study sponsored by UNDP/FAO on the 'Street Food Situation in Ghana'. A public health risk may therefore be associated with the consumption of such meals. However, partially ready meals, which are convenient and require less time for preparation, continue to be in demand in both developed and developing countries. The hygienic quality and safety of ethnic meals such as *waakye* can be assured through good processing practice and if necessary, irradiation. *Waakye* and other prepared meals can then be marketed under chilled or frozen

conditions, intended for microwaving prior to consumption.

There is therefore the need to investigate the microbial quality of w*aakye* and other ready-to-eat meals with the aim of identifying the possible sources and causes of contamination. This should provide base-line information to justify the application of irradiation for assured safety and shelf life extension under chilled or frozen conditions.

Objective:
To determine the microbial quality of '*waakye*' (rice and beans) and its accompaniments such as boiled macaroni, salads,fried fish, gravy/stew and moistened *gari*.

Work done, Results and Discussion:
Results indicated that *waakye* alone had aerobic plate counts ranging between 10^3 - 10^4 cfu/g and indicator organisms (VRBA) count of 10^1 - 10^2 cfu/g. Under refrigeration both aerobic and indicator organisms count increased. Aerobic count on boiled macaroni was $>10^7$ cfu/g, salads > 10^7 cfu/g, fried fish > 10^5 cfu/g and *gari* $>10^4$ cfu/g. The high microbial load of the accompaniments is note-worthy. Future studies will focus on measures to improve the microbial quality of the meals.

c. Classification of Different Cultivars of Cassava based on Starch composition, Cyanogenic Potential and Cooking Charateristics.

A. Owusu-Biney, J. Nketsia-Tabiri, R. Ahiabu, E. K. Osae, Y. Serfor Armah and B. J. B. Nyarko

Status: On-going

Justification
Starches possess characteristic properties which make them important industrial raw materials. They find applications in the food, textile, paper and polymer industries. Maize and potato as sources of starch have been extensively studied and applied in industry, but less so for cassava (*Manihot esculenta*) which is a staple food crop in many developing countries. Research and development in cassava breeding have resulted in a wide range of cultivars with improved characteristics in terms of yield and resistance to diseases/pests. While such improvements are necessary for increase in crop production, they do not guarantee their suitability for specific applications.

Objectives:
i. To determine the amylose and amylopectin content of the cassava starch.
ii. To determine the elemental composition of cassava starch.
iii. To determine the cyanogenic potential of cassava starch.
iv. To determine the gelation properties of cassava starch.
v. To identify the potential industrial application of the starches.

Work done and Results
Starch was extracted from 23 cultivars of cassava being screened by the Department of Plant and Soil Sciences of the Institute for various agronomical traits. Amylose content ranged between 13.0- 5.5% suggesting a range of 74.5 - 87.0% for amylopectin content. Spectrophoto-metric analysis indicated that phosphorus content ranged between 28.2 - 444.2 ppm. Neutron Activation Analysis indicated wide variations in the concentration of the elements; Na, Mg, Al, Cl, K and Ca occurred in relatively higher quantities (up 712 ppm) than Ti, Mn, Cu, Br, Ag and I. Concentrations of La, Au and V did not exceed 1 ppm in any of the 23 samples of starch. Cyanogenic potential of the starch samples ranged between 16.0-134.5 nmol while free cyanogen ranged between 5.0 - 94.5 nmol.

d. Evaluation of Breast Milk Intake of Infants and Body Composition of Lactating Mothers using Deuterium Oxide and Fourier Transformed Infrared Spectroscopy

D. Bansa, Anna Lartey, S. Timpo and P. Asamoa-Tutu

Status: On going (part of the IAEA TC No GHA/6/011: Human Nutrition Project)

Background and Justification

To address the endemic problem of malnutrition among pre-school children, pregnant and lactating women, the Ministry of Health in collaboration with the World Food Programme instituted a Supplementary Feeding and Educational Program (SFEP) in five of the ten regions of Ghana.
This project was initiated under this programme to assess the impact of food supplementation and nutrition education on the nutritional quality and growth of infants of lactating mother taking part in the SFEP.

Objective

To determine the breast milk intake of infants and body composition of mothers.

Work done and Results

Breast milk intake of three-month old infants was measured using an isotope tracer technique. A fixed dose of 30g of deuterium oxide was orally administered to the mother. Saliva samples were collected from mother and infant on days 1, 2, 3, 4, 13 and 14 after the administration of the deuterium. The samples were processed and deuterium enrichment measured using Fourier Transformed Infrared Spectro-meter. A two-compartmental model with respect to the movement of water through the mother-baby pair was used to obtain data on milk intake of the infant and body composition of the mother.

Results of the analysis indicate that there was no significant difference in the body composition of mothers on SFEP and those not on SFEP group. The mean breast milk intake of the total population (n=24) was 813.0(186.0g/day) and non-milk water intake was 331.0 (274.0g/day). The mean breast milk intake of infants with mothers on SFEP was 811.0 (175g/day) and that of those not on SFEP was 816 (205g/day). There was no significant difference between the two groups of infants. Non-milk water intake of infants of mothers on SFEP averaged 233.0 (131.0g/day) compared with 429 (345.0g/day) for those not on SFEP infants. There was a significant difference in the non-milk water intake of the two groups of infants.

The deuterium dilution technique was found to be a non-invasive, simple and safe method for measuring breast milk intake of infants. The method is especially useful for the estimation of breast milk contribution to nutrient intake in non-exclusively breast-fed infants. Milk intake by infants was found to be high. However, almost all the mothers did not exclusively breast-feed their babies as non-milk water intake was significantly high.

5.5.2.2 RADIATION PROCESSING PROGRAMME

The radiation processing programme focuses on the application of gamma radiation for the preservation and/or improvement in food quality, decontamination of water, spices and medical products/supplies. The projects under this programme primarily cover radiation control of biological causes of spoilage or loss of product quality, which include sprout inhibition, insect disinfestation and microbial decontamination.

a. Radiation effects on the sweet potato weevil, *Cylas* spp, and on sprouting of some Ghanaian cultivars of sweet potato.

Victoria Appiah and Alex Agyir-Yawson

Status: On going

Justification

In the previous study under NARP, irradiation dose of 100 - 200 Gy successfully controlled the sweet potato weevil in packaged sweet potato varieties: Sauti, (TIS 8266); Faara (TIS 3017), Okumkɔm (TIS 84/0320) and Santom Pona throughout the storage period of 11 weeks. A dose of 200Gy

inhibited sprouting of all varieties tested for a period of 12 weeks except in TIS 307 where sprouting was observed on the 12 weeks after storage. Thus response of varieties to irradiation varied. It is therefore important to continue this study to find out the extent to which the tubers can be kept and also to investigate further, the use of packaging material for export as well as the use of irradiation as a quarantine measure. The irradiated sweet potatoes also need to be evaluated in terms of their suitability for various dishes. As insect infestation often starts from the field, this study also seeks to study control in the field using bio-pesticides. In the current investigation under RTIP, two varieties being grown by the Horticultural Association for export are being evaluated.

Objectives

i. To establish dose mortality data for the egg and larval stages of sweet-potato weevils, *Cylas* spp, and to observe the effects of radiation on subsequent adult emergence and longevity of the adult beetle.
ii. To determine the effects of gamma radiation on the physiological and post-harvest quality of sweet potatoes and in controlling sprouting.

Work Done and Results

Two varieties of sweet-potato, Light and Deep Red (description based on peel color) were cultivated on a half acre plot for storage experiments. Ten tubers of each variety of sweet-potato were packaged in cartons measuring 33 x 22 x 12 cm in triplicates and irradiated at doses of 0, 50, 100, 150 and 200 Gy. Data collection is currently on-going on insect emergence, sprouting, rotting and weight loss at the different dose rates at different times.

b) Optimizing Processing Conditions for the Production of Irradiated Cured Fish

J. Nketsia Tabiri, Abraham Adu-Gyamfi; Kojo G. Montford, C.M. Gbedemah and S. Sefa-Dedeh (University of Ghana)

Project status: Completed IAEA Research Project (GHA 8869/R2)

Justification:

Curing processes such as salting fermentation and drying including smoking contribute immensely to the preservation and distribution of fish in most developing countries. The methods used are simple and have developed over the years according to local traditions. In Ghana, over 60% of the total fish landed is cured before being consumed. Cured fish products are relatively stable than fresh fish under ambient tropical conditions, however they suffer considerable losses due to insects, bacteria and moulds. Much of the loss has been attributed to inherent characteristics of traditional curing technologies. For example, smoked fish, which is stored by the traditional method, requires re-smoking at regular intervals to control microbial and insect proliferation. This practice, however, renders the final product excessively dry and susceptible to fragmentation with negative impact on sensory attributes. For processes which involve open sun-drying, the fish is susceptible to infestation by air-borne microbes and insects. Salting can reduce available moisture in the product and control microbial activity, but salt-tolerant bacteria *Halobacterium* and *Halococcus* inherent to solar salt persist on the fish and cause discoloration. Re-smoking and re-drying in the sun as measures for further reducing product moisture content and controlling microbial and insect activity are temporary and ineffective.These measures can be replaced or complemented with additional hurdles such as acidification and radiation treatment.

Objectives:

i. To determine the microbiological profile of traditionally smoked fish.
ii. To isolate, identify and determine D_{10} values for the organisms in order to establish the effective radiation dose for the preservation of smoked fish.

iii. To develop a ready-to-eat marinated fish product and in combination with irradiation ensure safety and shelf-stability.

iv. To determine water activity of ready-to-eat smoked sardines and marinated fish.

v. To evaluate the efficacy of retail and bulk packaging of smoke-dried sardines during storage under ambient conditions

Work done and Results

Microbes isolated from traditionally smoked sardines included *Staphylococcus sp.* (but not *Staph. aureus*) and *Klebsiella pneumonae ozaenae* which was found to have a D_{10} = 0.33 kGy. Others were from *Bacillus sp., Aspergillus sp., Penicillum sp. Absidia sp.,* Mucor and Yeasts. Microbes isolated from smoked tuna and mackerel included *Klebsiella pneumoniae; Bacillus sp; Enterobacter sakazakii; E. amnigena; E. aerogenes; E. cloacae; Escherichia coli; Staph. sp; Acinetobacter sp.; Proteus mirabilis; Serratia plymuthica; Psedomonas flourescens; Asp. niger; Asp. versicolor; Asp. wentii; Penicillium sp.; Erwinia sp.*

Ready-to-eat marinated fish (*Diplodus puntazzo*) was prepared by a combination of marinating in a solution containing 7% sodium chloride and 2% acetic acid followed with cooking in a thermostatically controlled oven. Water activity of the product ranged between 0.913 - 0.944. Irradiation (8 - 10 kGy) substantially reduced coliform count and extended the shelf-life and overall acceptability of the product by 3 days.

Water activity of unsalted soft-smoked sardines ranged between 0.923 - 0.986. Irradiation (7 kGy) extended shelf-life of the products from 3 days (for unirradiated samples) to 8 days. For the smoke-dried sardines, water activity ranged between 0.786 - 0.883. After 12 weeks storage, irradiated (7 - 11kGy) smoke-dried sardines with water activity between 0.764 - 0.857 were acceptable to consumers. The proportion of mouldy retail pack per carton of six packs ranged between 0 - 67%. Thus the impact of retail packaging on shelf life of smoke-dried sardines was that it limited spoilage to samples within the retail pack.

c) Updating Baseline Data on Commercially Irradiated Spices/ Dried Seasonings and Studies on their Microbial Stability during Storage

A. Adu-Gyamfi, Victoria Appiah, Josephine Nketsia-Tabiri and Stella Nkansah.

Status: On going and local Sponsorship
Funding: by BNARI through subvention

Justification

Spices and dried seasonings (SDS) serve as condiments that contribute immensely to the odour and flavour of foods. Although they are used in small amounts, their impact on freshly cooked and processed food is significant. The production of SDS is a highly lucrative global business venture. It is one of the emerging agro-industries capable of boosting the country's agricultural production and exports. Like most agricultural produce, they are frequently contaminated with enteric pathogens due to their unsatisfactory processing. This can cause quality and shelf-life problems for foods and subsequent health problems for consumers.

Irradiation of spices and dried seasonings has been demonstrated to significantly reduce microbial load without negatively affecting sensory and organoleptic properties. This will help local producers and exporters meet strict hygienic standards and quarantine requirements. Updating baseline data on commercially irradiated SDS in the country and subsequent studies on their microbial stability during storage would contribute to the development of a national database and further strengthen existing initiatives to support commercial activities with the relevant scientific information.

Objectives

i. To assess the microbiological quality of commercially irradiated spices and dried seasonings.
ii. To assess the effect of storage period on microbiological quality of spices and dried seasonings.

Work done and Results

The main spices and dried seasonings irradiated in the country are the powders of Pepper, Fish, Shrimp, Dawadawa, Cardamom and Peppercorn.

Microorganisms isolated from the spices and dried seasoning included *Aspergillus niger, A. versicolor, A. tamari, A. candidus, A. wentii, Rhizopus spp, Penicillium oxalicum, P. cyclopium, Geotrichum spp. Cladosporium herbarium,* yeasts, *Lactobacillus spp. Bacillus spp., and Clostridium spp.*

Treatment with 25 kGy gamma radiation reduced the microbiological load and rendered the quality of the products acceptable according to national and international standards of counts of $<10^6$ cfu/g for total viable cells and $<10^4$ cfu/g for moulds and yeasts. The average ranges obtained after analysis of 110 samples were total viable count (1.0×10^3 - 1.7×10^6 cfu/g for non-irradiated and <30 - 1.0×10^3 cfu/g for irradiated samples); Moulds and Yeasts (<30 -1.0×10^4 cfu/g for non-irradiated samples and <30 to 50 cfu/g Irradiated samples. Storage for up to 12 months did not affect the total viable count of all the spices and dried seasonings.

d) To Demonstrate the Efficacy of Gamma Radiation in the Improvement of the Sterility Assurance Levels (SALs) of Locally Produced Intravenous Fluids

C. M. Ghedemah, A. Adu-Gyamfi, Rose Boatin, A. Owusu-Biney, & B. Boateng (Intravenous Infusions Limited, Koforidua)

Status: On going

Justification

The production of intravenous fluids demands strict aseptic conditions. Although the fluids are aseptically produced, there is the risk of microbial contamination by certain gram-negative bacteria. International Standards and Procedures for aseptic production of intravenous fluids demand a sterility assurance level (SAL) of 10^{-3}. It has been established that low-dose gamma irradiation can further enhance the SALs to internationally accepted low values of 10^{-6}.

Objectives:

i. To demonstrate the effect of gamma radiation on the biochemical integrity and stability of intravenous fluids.
ii. Comparative assessment of gamma radiation and steam in the sterilization of bacteria-inoculated intravenous infusions.

Work done/Results and Discussion:

Investigations so far indicate that the low-dose gamma radiation treatment of intravenous fluids for the improvement of their hygienic quality is feasible. An optimum dose of 6 kGy for the treatment of the intravenous fluids guarantees biochemical stability.

e) Radiation Resistance Studies of the Microbial Profile of Some Smoked Fish

A. Adu-Gyamfi, J. Nketsia-Tabiri, S. Nkansah and Emi-Reynolds

Objectives

i. To determine the microbial profile of Smoked herrings, mackerel and tuna.
ii. To determine the radiosensitivity of the microbes forming the profile of smoked herrings, mackerel and tuna.

Work done and Results

The microbial profile of smoked herrings, mackerel and tuna was determined as: *Klebsiella pneumoniae, Bacillus spp., Enterobacter sakazakii, E. amnigena E. aerogenes, E. cloacae Staphylococcus spp., Aspergillus niger, A.versicolor, A. wentii, Escherichia coli, Penicillium spp., Erwina spp., Acinetobacter spp., Proteus mirabilis, Serattia plymuthica* and *Pseudomonas flourescens.*

The radio-sensitivity (D_{10}) of *Klebsiella pneumoniae* was calculated as 0.33 kGy.

f) Radiation Decontamination of Herbal Tea Products.

Adu-Gyamfi

Objectives

To determine the microbiological load and effective irradiation dose for microbial decontamination of three herbal tea products:

1. Dried milled roots of *Cryptolepis sanguinoleta.*
2. Dried milled leaves and stems of *Desmodium adscendens*
2. Dried milled leaves of *Lippia multifora.*

Results and Discussion

The microbiological loads of dried milled samples and the effective decontamination doses for the products were established as:

Herb	Load	Dose
C. sanguinoleta.....	2.0×10^8	15 kGy
D. adscendens	2.0×10^6	15 kGy
L. multifora.....	2.0×10^9	25 kGy

The most radio-resistant bacteria on these products were *Bacillus* spp. and *Pasteurella* spp., which survived irradiation at doses of 12.5 and 15 kGy. The microbiological loads of the products of *C. sanguinoleta* and *L. multifora* were found to be too high. Accordingly, it was suggested that the integration of good manufacturing practices into the processing protocols could improve the quality of the products and ensure *utilization* of lower irradiation dose of possibly 12.5 KGy.

5.5.2.3 FOOD AND ENVIRONMENTAL BIOTECHNOLOGY PROGRAM

This program aims at employing biotechnology to address food and environmental problems. Biotechnology basically harnesses natural biological processes involving microbes, plants and animal cells not only for the development and efficient production of foods especially novel foods (e.g. modified starch), biopreservatives, bioemulsifiers and biopesticides but also for environmental protection through the conversion of agricultural waste into useful products, bioremediation of polluted water and bioleaching of precious metals. In view of the fact that modern technology, specifically genetically modified organisms, have assumed global importance, the Food and Environmental programme also covers biosafety issues.

i. Biosafety Issues

BNARI, on behalf of the Ghana Atomic Energy Commission, is the Biosafety Focal Point for Ghana. Consequenty scientists of the Department have been involved in international discussions on the Biosafety Protocol of the Catagena Convention on Biological Diversity (CBD). Article 8 (g) of the CBD calls upon contracting parties to:

> "Establish or maintain means to regulate manage or control risks associated with the use and release of living modified organisms resulting from biotechnology which are likely to have adverse environmental impacts that could affect the conservation and sustainable use of biological diversity, taking into account the risks to human health".

As the Biosafety Focal Point, scientists from the department were involved in the development of the Draft Biosafety Guidelines (currently under review) which is one of the elements of the National Biosafety Framework. The other three elements of the National Biosafety Framework that must be developed are the administrative system, risk

assessment and management system and public participation and information system. Towards capacity building, scientists are also being trained in science and technology policy analysis in order to meet the varied demands of the CBD in general and the Biosafety Protocol in particular.

ii. Bioconversion of agricultural wastes into mushroom and animal feed supplements.

A. Owusu-Biney; C. Gbedemah, Y. Gomda and Josephine Nketsia-Tabiri

Justification

Agriculture is generally associated with large amount of by-products or waste, which if not utilized could create environmental problems. The degradation and assimilation of lignocellulose, the major component of agricultural waste, by the fungus, Pleurotus ostreatus, and its subsequent growth will not only provide mushrooms for consumption but also improve the nutritive value of the spent substrate for further processing into animal feed supplements.

Objectives

i. To conduct comparative studies on radiation treatment and conventional technologies for pretreatment of agricultural waste
ii. To isolate enzymes and study the mechanism of lignin degradation by Pleurotus ostreatus
iii. To develop protocol for solid state biotreatment of agricultural waste into feed or feed supplements using enzyme isolates

Work done and Results

Preliminary studies have indicated that gamma radiation could serve as both a decontaminating agent as well as a hydrolytic agent for sawdust prior to bionconversion into mushroom . Pleurotus spp.

Subsequent studies will depend on the establishment of efficient system for mushroom production. This has not yet been achieved primarily because of inadequate funding. Preliminary discussions on collaboration with private commercial mushroom producers have been initiated.

iii. Evaluation of Four Local Plant Species for Insecticidal Activity against some Insect Pests of Economic Importance.

A. Egyir Yawson, Alex Owusu-Biney and Charles Annoh

Status: On going

Justification

The need to find materials that effectively protect stored produce, which are affordable, relatively less poisonous and less detrimental to the environment, has turned the attention of entomologists and toxico-logists to locally grown medicinal plants. The effectiveness of certain plant derivatives against stored products insects have been amply demonstrated. Among them however, the *neem* tree *Azadiracta indica*, A. Juss, has received the most attention. The purpose of this study is the preliminary evaluation of the toxic effects of some local medicinal plants, other than *neem*, on some insect pests of stored produce and some field pest species.

Main Objectives

i. To assay for local plant species with insecticidal activity against some economically important insect species.
ii. To isolate and determine the active ingredients in candidate plant species that shows promise.
iii. Formulation of the active ingredients into possible biopesticides for field trials.

Work done

The study has focused on seeds of three of species, *Jatropha curcas* (Physic Nut), *Ricinus communis* (Castor Oil Plant) and *Erythrophleum suaveolens* (Ordeal Tree) and on nutshells of *Anacardium occidentalis* (Cashew Nut Tree).

The seeds and nuts were harvested dry and further dried at room temperature for seven days before being ground into powder and paste respectively. Powders and pastes were bagged in polyethylene bags and kept while

crude extracts were kept in the refrigerator until needed. Toxicity and repellency assays of crude extracts, direct powder and paste admixtures on *Callosobruchus maculatus* and *Sitophilus zeamais* were done.

Results

Preliminary results indicate insecticidal activity of *R. communis* and *J. curcas* against both insects either as direct admixtures or as topically applied droplets. *R. Communis* has significantly high activity against both insects at very low doses rates; however, *J. curcas* has low toxicity against *S. zeamais* at high doses but a relatively high toxicity against *C. maculatus* at very low doses. Activity levels were evident in powder and paste concentrations as low as 1.0-g of material/100 g of grain for R. *communis* in maize and 10.0-g of material/100-g of grain for *J. curcas* in cowpea. Adult emergence was completely prevented in powder and paste concentrations of the magnitude of 10g/100g of grain and above for both materials. Insecticidal activity levels of *E. sauveolens* and *A. occidentalis* did not follow any clear-cut pattern and hence for now, lack any logical explanations. The project is still on going and further results are expected next year.

iv. Molecular Techniques for the Diagnosis of Tuberculosis.

Achel D. G., Wilson, M. D., Gyamfi, O. K., Aboagye, S., Bonsu, F. A., Wilson, I. K. and Rose A. K. Boatin (BNARI).

***Status*: On going (part of the IAEA TC Project GH 6010 on "The Establishment of a Molecular Biology Laboratory for the Diagnosis of Tuberculosis in Ghana")**

Justification

The molecular mechanism of drug resistance in *M. tuberculosis* indicates that it is due to mutations in particular genes. Resistance to anti-tuberculosis drugs is a worldwide problem. The standard method of testing for drug resistance by culture is time consuming, for this reason, it is not routinely done in laboratories. This may lead to the spread of drug resistant strains.

Drug resistance is a major problem for some African and South American countries. Preliminary results (not reported here) suggest drug resistance may be a problem here in Ghana. The rapid diagnosis of drug resistance may help stop chains of transmission of multi-drug resistant strains, which is a threat to most societies. Molecular techniques can be exploited for the rapid diagnosis of TB.

Objectives

i. To use molecular techniques to diagnose tuberculosis in Ziehl-Neelsen negative (ZN-ve) sputum.
ii. To use molecular techniques for drug resistance studies in tuberculosis.

Work done and Results

PCR and culture studies were carried out on smear-negative sputum samples obtained from patients suspected of having tuberculosis. Sixty-three patients were enrolled in this study. The sputum samples were decontaminated and part of the suspension inoculated into Lowenstein-Jensen slants for the culture growth studies. DNA from *M. tuberculosis* (if present) was extracted from the remaining part of the decontaminated suspension. Extracted DNA was amplified by PCR and analyzed.

Unlike the conventional microscopy and culture techniques, this molecular technique reduced the detection or exclusion of the presence of *M. tuberculosis* DNA in sputum samples from three to six weeks (with microscopy and culture) to two days. The importance of this work is the ability of PCR to detect tuberculosis in smear negative samples. PCR could have a significant impact on the management of tuberculosis suspects and hence improve the efficiency of the national tuberculosis control programme.

In the absence of the final clinical diagnosis, PCR seems to perform better than culture in diagnosing tuberculosis among patients with low bacterial load and is therefore a valuable asset in the diagnostic facilities available to a tuberculosis laboratory.

v. Fighting poverty in Ghana through sustainable agriculture - the role of biotechnology

Josephine Nketsia-Tabiri and Alex Owusu-Biney

Justification:

Poverty, environmental degradation and food insecurity are the gravest challenges that developing countries must overcome. The 1996 World Food Summit acknowledged the deteriorating food and nutrition problems facing developing nations particularly those in sub-Saharan Africa which dominate the low-income, food deficit countries list. Thus the United Nations Millenium Declaration set out clear objectives including decreasing the number of hungry people in the world by at least 50% (from 790 million to 415 million) and eradicating poverty by the year 2015. However, the 2001 UNDP Human Resource Development Report brings to the fore the world's inability to eradicate poverty in the shortest possible time unless *revolutionary measures* are taken by poor governments. The FAO's position is that every available measure to improve food security should be used subject to careful assessments being made.

Objectives:

I. To identify causes of poor agricultural productivity and its impact on poverty in Ghana.
ii. To identify the impact of public policies on agricultural productivity.
iii. To identify the role that biotechnology can play to ensure sustainable agriculture
iv. To recommend policy options that can improve agricultural productivity on sustainable basis and reduce poverty in Ghana.

Work done and Results:

Inefficient marketing, high post-harvest losses, low level of agro-processing and high level of illiteracy among subsistence farmers were considered the major causes of low agricultural productivity. Economic policies implemented since1983, were considered particularly biased against subsistence farmers who produce over 70% of agricultural output and are therefore key to Ghana's food security. In spite of the fact that biotechnology can complement conventional breeding and farming practices to promote sustainable agriculture through a wide range of possibilities including high yielding potential, drought tolerance, resistance to pests and diseases as well as improved nutritional and industrial utilization at competitive cost, Ghana has not put in place the required policies to accelerate its commercial application.

It is recommended that Ghana focuses on strengthening agriculture and agro-industries through the institution of special credit facilities and vertical linkage of processing with raw material production. Furthermore Ghana must support the transfer of proven biotechnology innovations and direct research to adapt them, if necessary, to suit local conditions. These can be achieved through partnerships that accelerate application of biotechnology innovations and other technologies *in tandem* with human capacity-building in the technologies. Stakeholders' workshop is recommended to identify innovative ways to encourage the educated to take up agriculture as a business.

vi. Development of Ghana's Biotechnology Policy Framework: Some Policy Considerations

Alex Owusu-Biney and J. Nketsia-Tabiri

Justification:

Biotechnology is a key 21st Century technology for sustainable development. According to the survey carried out by the Department For International Department (DFID) of the UK which sponsored the Biotechnology Development Programme, Biotechnology is being developed and utilized in Ghana, but there is no policy framework. Such policies will help manage biotechnology in a systematic manner. There is the need to develop a policy framework to address the policy gaps and help provide the missing link to the uncoordinated ends in our national biotechnology development agenda.

Objective:

To generate information to contribute to the development of a National Biotechnology Policy Framework.

Work done and Results

An efficient development and sustainable use of biotechnology requires policies that manage technological development in a systemic and systematic manner. Policies on governance, research, investment in public sector facilities among others, need to interact with complementary policies to increase private sector investment, promote new exports and reform institutional structures and linkages. Such policies need not apply only to biotechnology but also other emerging technologies. Ghana's biotechnology development process has reached a stage where it is necessary to move forward with a biotechnology strategy to fill the gap and provide a medium to link the unco-ordinated ends in the biotechnology development process.

5.5.3 ANIMAL SCIENCE DEPARTMENT

5.5.3.1 ENTOMOLOGY PROGRAM

i. Radiation Induced Inherited Sterility of Lepidopterous Maize Stem-borers for Insect Pest Management Program in Ghana.

Charles E. Annoh

Background/Justification

Eldana saccharina Walker (Pyralidae) and *Sesamia calamistis* Hampson (Noctuidae) are two lepidopterous maize stemborers in Ghana, known to be very destructive field pests of maize. They contribute to high losses of maize, between 10% -100% annually. Currently, control of the pest is achieved almost entirely through the use of synthetic insecticides, which is usually costly and has serious environmental repercussions. Due to the difficulties encountered in controlling the stem borers through conventional methods it would be of great interest to use other alternative methods of control. One of such methods is to ascertain the effect of gamma radiation doses on the parent (P_1) pests, usually the pupae and the feasibility of applying inherited sterility, for suppression of the borer species. Similar investigations had been performed by other researchers on several lepidopterous species including cabbage lopper, *Trichoplusia ni* (North and Holt, 1969), the corn earworm, *Helicoverpa zea* (Boddie) (Carpenter and Gross, 1993), codling moth, *Cydia pomonella* (Bloem *et al.* 1999). The research project was therefore aimed at developing inherited sterility in *E. saccharina* and *S. calamistis* and combine with other biological control methods for suppression of the pest population.

Objectives

i. To study the infestation levels of larvae/pupae of *E. saccharina* and *S. calamistis* in maize farming systems in the Ga District of Greater Accra Region.
ii. To perform and observe effects of sub-sterilizing doses of ionizing radiation on the biology of the two borer species and determine levels of inherited sterility of the F_1 progeny.
iii. To develop and establish laboratory rearing facility for mass rearing of the bore species for F_1 sterility.

iv. To conduct field-cage studies for determining the right proportion of sterile to normal ratios of the borer species to suppress the pest population.

Work Completed with results

Field sampling of larvae/pupae of the two borer species to determine infestation levels in the field has been conducted for the period of 1997, 1998, and 1999. Results showed that pest infestation was quite high during the short rainfall and dry periods in maize ecosystem at Medie in the Ga district.

Ionizing radiation of sub-lethal doses at 80, 100, 120, 150 and 180 Gy respectively were applied separately to pupae of ages between 2 and 8 days old. Juvenile pupae of ages less than 6 days old showed high percentages of bodily deformities and non-emergence of adults (from pupae) with increasing doses of radiation. Mature pupae (6 - 8 days old) showed high percentage adult emergence with little or no bodily deformities as radiation doses increased. Emerged male and female moths from treated mature pupae (T) were put-crossed with untreated (normal N) fertile moths of the opposite sex. Fecundity of parent moths (P_1) and F_1 progeny reduced considerably with increasing doses of radiation. Increasing doses of radiation resulted in significant reduction of fertility for all treated moths of P_1 and F_1 progeny.

Larvae were reared on natural and artificial diets and performance compared. Differences in mortality, fecundity, and other biological parameters were not significant between the two diets.

Cytogenetical study was conducted on testes of treated and untreated late-instar larvae of *E. saccharina*. Results showed chromosomal aberrations in the form of rings and fragments, in treated ones.

Work On-going

Field cage experiments on sterile to normal ratios and statistical analysis and result write-up are on-going.

Beneficiaries

Maize growers/farmers at Medie, in the Ga District would be direct beneficiaries on successful completion and conducting of field trials of F_1 sterility. Suppressions of the stem borer species would lead to higher maize yields for the entire popula-tion. Researchers, Agriculture Extension officers and farmers could apply the technique to control other insects of economic importance that infest cereals like sorghum, rice, millet etc.

ii) Control of Riverine Tsetse Flies based on Community Participation in Trapping Technology and Sterile Insect Technique (SIT) in the Savelugu-Nanton District, Northern Ghana

Delphina Aba Adabie-Gomez

Project status: On-going and funded locally through subvention

Background

Tsetse flies, *Glossina* species, are found in all ten regions of Ghana, but are known to be a serious threat to the livestock and tourism industries in three regions (Upper West, Upper East and Northern) in the northern sector of the country, where 75% of livestock and most of the game reserves are located. The flies contribute to high losses in livestock production, malnutrition due to shortage of milk, meat and other dairy and animal products. Their presence in high densities and painful bites are a great nuisance to both farmers and tourists. In addition, the disease they transmit to both livestock and humans have great negative impact on health and agricultural production and the economy. Savelugu-Nanton District is one of the four priority areas that have been identified for tsetse control in the country. Currently, the control of the flies is achieved through the use of insecticides applied to their breeding habitats, animal hosts or to artificial targets/screen and by trapping the flies using biconical, monoconical and/or pyrimidal traps. These

methods have not succeeded in eliminating the tsetse and trypanosomiasis problem. There is therefore the need to find more effective and efficient alternative control methods that are environmentally friendly, target-specific and cost-effective. The project is therefore aimed at developing the Sterile Insect Technique (SIT) to be used as a key component in the integrated control of tsetse flies in the country and thereby control trypanosomiasis and its effects on agriculture and other socio-economic development of the country.

General Objective

To alleviate the trypanosomiasis constraint on livestock production in Ghana within the broader context of food security, human and animal health, rural development and sustainable agriculture through the control of tsetse flies, the vectors of trypanosomiasis.

Specific Objectives

i. To develop and apply gamma radiation induced sterility (SIT) for the control of two closely related riverine tsetse flies along two river systems in the Savelugu-Nanton District in the Northern Region of Ghana in order to alleviate trypanosomiasis which affects both humans and domestic animals.

ii. To make some fertile lands free of tsetse flies to allow for increased crop and livestock production to increase meat and milk yields thereby increasing income and reducing poverty of livestock farmers and malnutrition among the populace.

Work done and Results

The pre-release suppression of natural populations of two tsetse species, *Glossina palpalis palpalis* and *G. tachinoides* along two river systems in the Savelugu-Nanton District in the Northern Region of Ghana continued using trapping and [illegible] technologies. Eleven rural communities participated in the deployment of the baiting technology. They were trained and mobilized to use the chemical-treated screens in and around their settlements and in their farms and kraals for the control of tsetse and other biting insects. All the targeted communities and some individuals now own some targets/screens for their own use. This is a clear indication that the technology has been accepted and adopted by the farmers and rural communities.

Maintenance of the laboratory colony of the tsetse flies on guinea-pigs continued in order to have flies for mass rearing and releases in future.

Expected outputs

- Tsetse flies controlled to alleviate the trypanosomiasis transmitted by the flies.
- Health of both humans and livestock improved.
- Agricultural and livestock productivity increased to ensure food security.
- Tsetse-free areas provided for promotion of other socio-economic activities to create wealth and reduce poverty and improve quality of life.

Programme Performance (key outputs and Impact)

The transfer of the impregnated Screens and Target Technology to the eleven rural communities in the Savelugu-Nanton District in the Northern Region for tsetse population suppression is 100% completed.

The populations of tsetse flies in eleven communities in the Savelugu-Nanton District have been reduced to less than 20%.

Beneficiaries

Successful completion of the project would benefit both crop and livestock farmers since the tsetse population suppression would lead to healthier animals and higher production of milk and meat and eventually lead to wealth creation and poverty alleviation.

The general population will also benefit from availability of animal products at affordable

prices leading to increase intake of protein to alleviate malnutrition and improve health and productivity.

Constraints

i. The monitoring of dispersal and longevity of the 1000 sterile males released in the previous year, and related surveys on trypanosome prevalence in both cattle and tsetse flies could not be carried out. This was due to lack of logistics support for field work during the period under review. Hence the assessment of the impact of the deployed screens on the tsetse population and disease infection rates in livestock could also not be carried out.

ii. Both Gamma radiation facilities (the Multi-purpose and 220 Gamma-cell Cobalt-60 source) for the sterilization of blood for feeding flies and for induction of sterility in male flies for releases were out of operation for greater part of the year under review. Therefore, further mass rearing of the flies (which depended on irradiated blood) and field releases of sterile males could not be done as scheduled.

iii. The SIT component of the project was suspended because of blood collection problem at the Accra Abbatoir and lack of vehicles at critical times.

Projections

The laboratory rearing of tsetse colonies will be stepped up to mass produce sterile males for releases during the coming years.

The pre-release suppression of the natural tsetse population by insecticide-impregnated screens and targets carried out by the rural communities will continue. This phase of the project will be expanded to enable other tsetse infested communities in the region to take active role in protecting themselves and their animals from diseases transmitted by tsetse flies and other biting insects their communities.

Surveys on trypanosome prevalence in both cattle and tsetse flies will be carried out in order to assess the impact of the deployed screens and sterile releases on the tsetse population and disease infection rates in livestock. Impact of the control programme on other socio-economic parameters will also be carried out.

Field trials of the SIT to control the two tsetse species will be extended to other infested priority areas in the country where cattle production is going on. The technique could then be adopted for the control of other dipterans insects of economic importance such as mosquitoes and houseflies.

iii) Livestock and Crops Production Systems and Vector Control Programme in Ghana: A Case Study of the Ho District in the Volta Region

Delphina Aba Adabie-Gomez and Samuel Edudzi Timpo

Project status: New, an extension of the tsetse project to other priority areas of the country.

Background

As mentioned elsewhere, tsetse flies are found in all ten regions of the country and four priority areas have been selected for tsetse control using a combination of methods including SIT. To institute a control method for a particular insect pest in any area, there is the need to have relevant baseline data on the agricultural activities as well as the entomological, epidemiological and ecological situations. This new project was then started to gather the relevant information needed to design appropriate strategy for tsetse control using the SIT.

General Objective

To prepare the ground to extend into the Volta Region activities aimed at alleviating the trypanosomiasis constraint on livestock production within the broader context of food

security, human and animal health, rural development and sustainable agriculture through the control of tsetse flies, the vectors of trypanosomiasis.

Specific Objectives

i. To conduct a rapid appraisal study to test a farmer questionnaire in four communities in the Ho District in the Volta Region.

ii. To develop a framework for widespread dissemination of tsetse bait or trapping technology.

iii. To determine whether the communities, relying on their own financial and management resources, are willing to alleviate trypanosomiasis by using screens to control tsetse flies.

Work done

Survey: Four selected rural communities, two villages (Banfora and Agbokofe) in the Takla traditional area and two (Adakofe and Golokofe) in the Adaklu traditional area, were selected for the study. A rapid appraisal study was conducted to test a questionnaire on the following issues:- (a) socio-economic characteristics of farmers; (b) Crops production and management systems; (c) Livestock production and management systems and (d) Farmers' knowledge, attitudes and perception of the tsetse and trypanosomiasis problems and vector control practices. During the survey, blood samples were collected from some cattle to determine their health status in the area. Five biconical traps each were also set up in the communities to detect the presence and relative abundance of tsetse flies in the area, if any.

Educational Campaign: To facilitate future adoption of tsetse control technologies, educational campaign was undertaken to raise their awareness of tsetse and trypanosomiasis problem and to get them to accept the responsibility for devising appropriate action to solve it. Topics covered in the campaign included the: -

1. effect of tsetse and trypanosomiasis on the health of the human and animal populations.
2. methods available for controlling tsetse flies and trypanosomiasis - focussing on the advantages and disadvantages of each method or technique.
3. benefits to be derived from tsetse control based on the active participation and generous contribution of the whole community.
4. relative costs of different traps, the blue cloth screens and black cloth and white netting targets to enable the communities to decide on the device that they would like to adopt in their area for the control of tsetse flies.

Formation of Tsetse Control Committees:

The project intends to involve communities in raising and controlling the required resources for managing tsetse flies using low-cost traps and screens. In enabling farmers to cooperate among themselves and with outside agencies, a ten-member Tsetse Control Committee (TCC) was set up in each community. The members would be trained by the researchers on how to construct the screens, treat with chemical and deploy them in the field. Each committee will then have the responsibility: - to train other members of their commu ity on how to use and maintain the screens; to liaise between the community and external agencies; to mobilize the community to participate and contribute (funds and labour) to the control program; to coordinate traps/screens deployment and other activities related to tsetse control in their area; and to also mobilize communities to participate in project review activities.

Results

Socio-economic characteristics of farmers

Most households in the four villages are male-headed. Farmers' age ranges from 18 years to over 70 years. Though men and women partake in crop farming, livestock rearing appears to be a male preserve particularly so for cattle. Most farmers rely

on self-finance for farm expenditures. The major non-farm income generating activities are charcoal making, food processing, firewood cutting and the splitting of the African Fan Palm (*Borassus aethiopum*) branches for sale as fencing and roofing materials, and the leaves as material for fan and thatch. Illiteracy is high among older farmers, while most of the young farmers seem to have had at least a few years of formal education from schools in villages nearby. The farmers lack access to portable water and depend on dams. Unfortunately, the inhabitants have to share these dams with domestic animals (especially cattle) during the periods of water scarcity, particularly in the dry season. These animal defaecate in the water and litter the banks. The housing type is predominantly mud with thatch roofing. Though the national electricity grid passes through the villages, they do not have electricity because they are yet to be connected. In terms of road accessibility, Agbokofe is easily accessible all year round, but Golokofe and Adakofe can be accessed with some difficulty at the peak of the rainy season. The only routes there are paths created by vehicles of butchers who frequent the place to buy cattle. Farmers in Agbokofe and Bamfora have had no contact with MOFA's Field Extension Officers. However, Extension Officers have until recently been assisting farmers in Adakofe and Golokofe,

Crop Production Systems and Farm Management Practices

The major crops grown by farmers are maize, cassava, groundnuts, sweet potatoes, yam, cocoyam, vegetables, banana and plantain. These crops are cultivated either in pure stands or as inter-crops. The average farm size is a hectare. The mode of land acquisition is by *abusa* system of sharecropping where the farmer takes two-thirds and the landlord takes one-third of the harvests.

The major farm inputs are cutlasses and hoes. Most farmers cannot afford the use of weedicides and chemical fertilizers. Though manure from livestock is available for use as an alternative to chemical fertilizers, the farmers do not use it, because of the belief that the manure is a potential source of seeds of all kinds of weeds which later pose serious husbandry problems on the farms. The types of labour used on farms are family labour, hired casual labour and reciprocal labour. Farmers do not use bullock plough. The few, who can afford, hire tractors for ploughing services.

Impact of wild and domestic animals on Crop Farming: Wild animals such as monkeys, grasscutters, squirrels and birds, which are found in the area, hinder farming activities. These animal attack crops from day of planting through to harvest time. The most troublesome of these animals are the monkeys, which are able to post spies in trees to warn others of approaching humans and thus avoid being caught or killed. They do not only eat farm produce, but wantonly destroy the rest of the crops. To curb this, the farmers use traps, scarecrows, guns and sometimes even send their children to the fields to scare or drive these animals away from their crops.

Cattle, sheep and goats are also a source of nuisance to crop farmers. To minimize this conflict, farmers in Agbokofe have agreed to farm on one side of the road and allow the animals to graze on the other side. Another coping mechanism adopted by the farmers is to make their farms distantly away from home. In spite of these measures, the animals still stray onto the farms and cause damage. Crop farmers sometimes react angrily by resorting to attacks on the animals with cutlasses and guns. In some cases the animals are caught and sent to Ho Town Council for fines to be imposed on the animal owners.

Livestock Production Systems and Management Practices

Role of Genders and Hired Labour: Farmers rear cattle, sheep, goats and poultry. Animals

are reared mainly for income and sold as and when the need arises. Other reasons for keeping animals are for food (source of milk and meat), as a tradition and for ceremonies.

The roles of family members in livestock production appear to be well defined. Men undertake all activities related to cattle rearing. These include sending cattle out to graze, watering them, administering medication and milking them. Women are tasked with processing fresh milk and preparing meals for the men herding the cattle. Male children help in milking, dipping and manoeuvering cattle into position for milking and dipping, while the female children assist in milking, carrying milk to the women for processing and in cases of labour inadequacy, assist in manoeuvering cattle into position for milking and dipping. Labour is hired periodically to complement that which is offered by the family members. The hired labour is usually a Fulani herdsman. The employer normally provides food and shelter for the hired hand as well as pays his wages and medical bills.

Livestock breeds and their Housing: The commonest breed of cattle is the Sanga (Fulani = Boboge), which is a hardy animal that copes well with hunger and diseases and has the ability to stay at one place for long periods. Other breeds are the Gudali and the West African Short Horn. Farmers believe that the Gudali breed is also suited to rearing conditions in the locality. It has the advantage of being bigger than Sanga hence sold at a higher price. A breed that farmers wished they could rear in the locality is the red-coated cow (Fulani = Bodege). This animal has a uniform red coat colour, is bigger, obedient, gives more milk, has majestic-looking long horns and general aesthetic value and cannot be easily stolen as it takes instructions from only the herdsman. Farmers have been deterred from rearing these red-coated cattle because of its susceptibility to diseases and its restlessness when confined for a period of time. Farmers do not keep records of flock numbers. They claim not to know the actual number of animals they have but can readily tell if any is missing. However, farmers apparently keep about a hundred cattle in each kraal.

Cattle are kept in kraals, whiles sheep, goats and poultry sleep in the open compounds of houses. In some cases, poultry also sleep on trees in the houses or fields. Cattle are sent out to graze all year round and are fed exclusively on grass. However, during periods of severe drought and grass scarcity, farmers send their cattle to other areas for about a month. A normal day for a herdsman starts at about 2 a. m. when cattle are sent to graze. The animals are brought back to the kraal at about 8 a.m. for milking, drug administration and rest. After about three hours of rest, they are sent back grazing till 5 – 6 p.m. after which they are rested till 2 a. m. the next day. Livestock management problems are referred to Veterinary Officers who are available on call. The most expensive input in cattle rearing is the veterinary drugs, which are purchased from Ho and sometimes from Togo.

Farmers' Knowledge, Attitudes and Perception of Tsetse and Trypanosomiasis Problem and their Control

Tsetse and their Control: Generally, farmers believe the tsetse fly and other biting insects exist in their locality and are a source of nuisance and discomfort from both noise and bites. However, farmers have little knowledge of the actual effects of bites of tsetse flies. This they attribute to the proliferation of all biting insects in the localities about the same time, which makes it difficult to know which ailment to assign to a particular insect. One thing they know for sure is that these insects appear in their numbers when the rainfall season is at its peak. The peak period of tsetse appearance is believed to be in June. From the farmers' viewpoint, there are two types of tsetse flies in the area, one big and one small. Further probing revealed that what the farmers call the "big tsetse fly" is actually the horse fly,

while the smaller one is the real tsetse fly. The twenty (20) biconical traps set up (5 in each of the four villages) in April to detect the presence of tsetse did not trap any tsetse flies, but caught mostly house-flies, honey bees, horse flies, grasshoppers and ants.

To control tsetse flies, farmers use smoke as a repellent in kraals and dip the animals in a chemical (Triatix), However, no preventive or control measures exist to protect the farm households.

Trypanosomiasis and its control: Farmers in Adako*fe*, Agboko*fe* and Goloko*fe* believe trypanosomiasis is a major problem in their area, while those in Bam*fora* claim the disease was a problem in the first three years of rearing cattle, but the disease incidence declined in subsequent years. The symptoms of the disease identified by farmers are sores, itches, anaemia, black spots, foetal abortions, boils, general ill-looking of the animal and sleeping sickness. The sources of the disease, it is believed, are cattle and weeds. However, farmers do not control trypanosomiasis or know of any control measure. It appears no control measure for the vector and disease or education in this regard has ever been introduced in these villages either by government or non-governmental bodies.

Farmers' Preferred methods for Tsetse and Trypanosomiasis: The farmers' preferred means of tsetse control were the (a) insecticide-impregnated screens or targets, (b) trapping to kill the insects to feed poultry, while (c) the administration of trypanocidal drugs appeared to be popular for the disease control.

Willingness of Farmers to participate and contribute to vector control programme: Farmers wish international development aid agencies would support integrated control of the vectors and the diseases they transmit by supplying drugs and providing technical support. They are prepared to provide food for workers, labour, black cloth, sticks and twine for deployment of the insecticide-impregnated screens and targets. TCCs were set up in Agboko*fe* and Goloko*fe*. Ban*fora* is a one-man settlement so a TCC could not be set up there, however, the farmer agreed to work with his family to help control tsetse flies and trypanosomiasis among his cattle.

Farmers' Major Problems: Major problems identified by the farmers are (a) access to portable water, (b) access to quality but affordable inputs and (c) an arrangement for peaceful co-existence between crop and livestock farmers.

Concluding remarks

Farmers were very cooperative and expressed hope that the programme will be followed through to a successful end. The 15-page questionnaire appeared lengthy hence a need for it to be abridged. The questions and their respective close-ended responses also need modification. There is also the need to modify the individual farmer questionnaire into a focus group interview schedule.

5.5.3.2 ANIMAL NUTRITION PROGRAMME

Isotope aided study on animal nutrition: A systematic mapping survey of forage and animal tissue using Neutron Activation Analysis (NAA) to locate mineral deficiencies and excesses in the communal grazing areas.

Y. M. Gomda, E.K. Osae (NNRI), E. H. K. Akaho (NNRI), F. K. Fianu (UG) and N. Karbo (ARI)

Project Status: on-going

Main Objectives:

i. Employ nuclear reactor facility to establish mineral element deficiencies in the communal cattle grazing areas.
i. Draw up a map indicating the areas of deficiencies and excesses.
ii. Recommend appropriate ways of combating mineral deficiencies and excesses through strategic feeding

supplementation for various regions in the country.

Methods and Main Results

Laboratory analysis of the samples from the field continued. The sera from the one hundred and forty nine (149) cattle, taken from the Northern, Upper East and West Regions needed to be freeze-dried before irradiation could take place. Unfortunately, freeze dryer was not available and this stalled the work.

Work plan for 2002

The Department of Food Science and Radiation Processing has taken delivery of a freeze dryer. This will enable the laboratory analysis to be continued and to bring the project to a close in year 2002.

Beneficiaries

- Livestock owners
- Ministry of Food and Agriculture
- Agricultural Research Institutions
  - Universities

Conclusion/Comments

Despite the lack of and breakdown of equipment at the Reactor Centre which affected the progress of the work. It is hoped that progress will still be made in the coming year in order to bring the project to a successful end.

5.5.3.3 ANIMAL REPRODUCTION AND HEALTH PROGRAM

i) The Effect of Management on Bovine Dermatophilosis on Friesian-Sanga Crosses in Herds on the Accra Plains of Ghana.

Charles des Bordes

Project Status: This project is an off an on-going AFRA Project RAF/5/046 "Increasing and Improving Milk and Meat Production".

Objective

The main objective is to improve the survival rate of offspring of the Artificial Insemination Programme (AIP) and thus increase productivity and profitability in milk and meat production.

Background information and Work done

The offspring of the AIP (Friesian/Sanga crosses) are known to have a higher morbidity and mortality of the bovine skin disease, Dermatophilosis than the purebred indigenous cattle. This has made the use of AI using semen from exotic bulls unattractive to many farmers. The disease is associated with the tick *Amblyomma variegatum*. It has been suggested that crossbred animals on farms with improved management have a lower morbidity of the disease than those on farms with not so good management. It was decided to collect data on mortality and morbidity rates on farms with different managerial techniques to see if any statistical inferences could be drawn on management and prevalence of dermatophilosis on these farms. Data was collected during the rainy season when the incidence of the disease is very high.

General Problems

1. The AFRA Project RAF/5/046 on "Increasing and Improving Milk and Meat Production" has been suspended owing to very low patronage of the AI services in the country. There ia an urgent need for the Extension Services of the Ministry of Food and Agriculture to educate farmers more on the benefits of using AI in cattle production.
2. Lack of transportation and communication between the AI center and the farms make the technology inaccessible to many farms.
3. The high incidences of bovine dermatophilosis among the crossbred offspring make AI unattractive to many cattle owners.

ii) Epidemiological Survey of Bovine Babesiosis in Ghana Using ELISA

technique and the Development of Recombinant Vaccines against the disease.

Musheibu Mohammed-Alfa

Project Status: On-going

Background/Justification

In order to achieve the National goal of increasing livestock productivity so as to meet the protein requirements of the populace, there is the growing tendency to introduce grade Cattle, usually genetically improved, to boost milk and meat production. These exotic breeds of Cattle. however, are very susceptible to tick-borne disease including *babesiosis*.

Bovine babesiosis as a haemoparasite disease if left unchecked can be the cause of anaemia, physical weakening and reduction in food intake leading to poor general condition of the animal resulting in reduced productivity. The possible economic losses would include not only the purchase price of these expensive imported breeding cattle but also the potential contribution of these animal to the genetic improvement of the National Herd.

The above stated problem clearly underscores the need for a closer look at the prevalence of bovine babesiosis amongst cattle in the country and the provision of an effective but affordable vaccine to confer immunity in anima.

Objectives

i. to establish the distribution of Bovine babesiosis in Ghana.
ii. to determine the seasonal incidence of bovine babesiosis in Ghana
iii. to develop a safer, more effective recombinant vaccine against bovine babesiosis.

Methods and Main Results

Contacts were made with ten Cattle Farms in the Accra plains and the Volta Region to conduct survey of bovine babesiosis prevalence. Five Kraals in the Banfora area of the Ho district were covered in the Survey. Blood was taken from 137 cattle, amongst them 126 cows and 11 Bulls. Serum was extracted and stored in serum bank.

The communities involved in the care for the animals were educated on the significance of regular tick control.

Constraints

Some financial assistance would be needed to make trips to other areas within the Region.

Work plan for 2002

Completion of sample-taking in the Accra plains and Volta Region and analysis of serum samples will commence.

Beneficiaries

The Ministry of Food and Agriculture would be direct beneficiary. Improved understanding of the distribution of bovine babesiosis in the country would help the Ministry to plan more effectively the introduction of imported breeding Cattle.

Farmers could apply the improved recombinant vaccine to effectively control bovine babesiosis.

iii) Survey of Drugs available for the Treatment of Canine Helminthiasis in Gha[illegible]

Franklin Kufe and C. K. desBordes

Project status: This is a collaborative project with CSIR/ARI, VSD/MOFA, NMIMIR and Korle-Bu Teaching Hospital Tuberculosis Clinic. Technical support and funding are expected from BNARI and other external institutions like the IFS – Sweden, and the Third World Academy of Science. This proposal has also been presented to AGSSIP for support.

Objective:

i. To find out the different types of drugs available on the market for the treatment of canine in Ghana.

ii. To select a few of the commonly used drugs and test their efficiency on naturally infected dogs in the Greater Accra Region.

Work Done and Results

The project started in September 2000 with a survey carried out by visiting the shops of the big importers of Veterinary drugs to find out the common antihelminthics for dogs that are imported into the country. A similar survey was carried out on the big pharmaceutical firms that import or manufacture antihelminthic drugs meant for human helminthoses.

It was noted that majority of the pet owners contacted do not know about the zoonotic implications of their failure to regularly worm their pets. One major reason noted is due to high drug price. A few more potent and cheaper wormers have been selected and being monitored for their efficiency on naturally infected dogs in the Greater Accra Region.

Future projections

Complete work on the antihelminthes and recommend cheaper and more potent wormers for pet owners.

iv) Studies on the Zoonotic Implications of Bovine Tuberculosis in Peri-Urban Small Dairy Holder Units in Ghana using the PCR

Franklin Kufe

Objectives

(i) To find out the spec of Tuberculosis organism prec in cattle within peri-urban dairy units and the extent of infection in Fulani Herdsmen and raw-milk sellers.

(ii) To culture & speciate *Mycobacterium* from raw milk produced from peri-urban cattle herds.

(iii) To isolate & speciate *Mycobacterium* from the sputum of human tuberculosis cases and establish the prevalence of *M. bovis* infection in humans.

Work Done

Some milk samples have been collected and stored for future analysis.

Some herdsmen and their close relatives have been educated about the dangers of drinking raw milk from cattle and the zoonotic implications of bovine TB.

Future projections

To establish the prevalence of bovine TB in human TB cases and make the necessary recommendations to the Government.

5.4 NEW RESEARCH PROPOSALS

The following research proposals were prepared in collaboration with other scientists in BNARI and other national research institutions and submitted for possible funding:

1. Biological Control of Maize Stem-borers: Lepidopteran F1 Sterility with Released Parasitoids.

Mr. Charles Annoh

Concept paper submitted to AGSSIP on 13/12/2001. (Budget = $22,000.00).

2. Area-wide integrated control of Riverine tsetse flies using Bait Technology and Sterile Insect Technique.

Dr. Mrs. Delphina A. M. A. Gomez

Submitted to IAEA for Technical Assistance for period 2003-2005. Budget=$90,800.00

3. **Encyclopaedia of Traditional Uses of Insects in Sub-Saharan Africa** submitted to ASA/ICIPE on 27/11/2001. (Budget = $237,750.00).

Dr. Mrs. Delphina A. M. A. Gomez

4. **Transfer of Bait Technology to Rural Communities for Insect Pest Management and Improved Agricultural Production**

Dr. Mrs. Delphina A. M. A. Gomez
Concept paper submitted to AGSSIP on 20/12/2001. (Budget = $52,000.00).

5.Development and Use of Recombinant DNA Vaccines in the Control of Foot and Mouth Disease of Cattle in Ghana.
M. Mohammed-Alfa and Franklin Kufe

The objective is to identify immunogenic antigens of Foot and Mouth Disease Virus and develop recombinant DNA vaccine against the disease in cattle. This is a collaborative venture with the Veterinary Services Division of the Ministry of Food and Agriculture. The proposal has also been sent to IAEA for approval and support, but to date no positive answer has been received. This report is a repetition of the previous year because we would like to draw the attention of the BNARI Scientific Committee and solicit assistance to enable us develop the capability of producing recombinant DNA vaccines and commercialize them.

6. **Commercial Production of Recombinant DNA Vaccines**

Dr. F. Kufe and Dr. M. Mohammed-Alfa

The Objective is to establish a Molecular Biology Laboratory in BNARI for the commercial production of Recombinant DNA Vaccines against major Livestock and Zoonotic Diseases in Ghana. This is a project proposal sent through BNARI Director to the Ministry of Food and Agriculture for assistance in the establishment of a Molecular Biology Laboratory in BNARI for the commercial production of Recombinant DNA Vaccines against major livestock and Zoonotic diseases in Ghana. There seems to be a general support by the Government of Ghana for Biotechnology in GAEC and we therefore hope our project proposal will receive the necessary attention from MOFA and thereby promote inter-sectoral collaboration and cooperation. We also hope that the Commission will assist the Institute to establish a Molecular Biology Laboratory at BNARI/DAS as a matter of urgency for research and commercial production of Recombinant DNA Vaccines for prevention and treatment of diseases of both humans and livestock.

7. **Radiation Sterilization of Traditional Medicine Drugs in Ghana**

A. Adu-Gyamfi

A collaborative research proposal, with the Centre for Scientific Research into Plant Medicine (CSRPM). The proposal will be forwarded to the IAEA, WHO and other relevant international and local institutions/agencies for funding.

8. **The Use of Radiation Sterilized Human Amniontic Membrane and Porcine Xenografts in the Treatment of Wounds.**

A. Adu-Gyamfi

Efforts will continue to source for funding from the IAEA, Ministry of Health, and Phyto-Ryker Company Limited to initiate this project in 2002.

9. **Cost-benefit studies on radiation preservation of yams for domestic and export markets.**

J. Nketsia-Tabiri, S. Timpo, Victoria Appiah, A. Owusu-Biney, A. Adu-Gyamfi and G. Emi-Reynolds.

Justification

Ghana enjoys comparative advantage in yam (*Dioscorea* sp.) production Consequently, the crop is the country's second most important export crop. Yam exports in 2000 earned Ghana $7.2 million. Indications however are that, the inefficient post-harvest storage of yams have been linked to the low level of yam processing into value-added products.

Due to the poor storage stability of yams, farmers are anxious to sell their produce soon after harvest with low economic returns. This problem has ever caused the Ghana Yam Exporters Association to advise her members to regulate quantities exported. Attempts to minimize post-harvest losses include improvements in yam barns to facilitate adequate ventilation as well as measures to inhibit sprouting.

Earlier studies indicated that low dose radiation (150 Gy) effectively inhibited sprouting and controlled dehydration and loss of weight by the yam tubers for 6-9 months without affecting the eating quality. These studies however did not investigate the profitability of irradiation technology as well as profitability to farmers, both of which are crucial to technology adoption.

Objectives

i. To estimate the costs and returns of irradiated yams compared to non- irradiated yams.

ii. To estimate the cost of irradiation to farmers and yam handlers

iii. To assess farmers and yam handlers willingness to pay for irradiation treatment.

Expected Outputs

i. Profitability of irradiation treatment of yams established.

ii Farmers and yam handlers adopt irradiation technology.

iii. Willingness of farmers' and yam handlers to pay for radiation treatment established.

Estimated Cost = US $13, 450

5.5 SUSPENDED PROJECTS

The following projects have been suspended due to lack of basic equipment items and funding:

i. Production of Bacteriocin from lactic acid bacteria

ii. Bioleaching of Preciuos metals in Ghana with special emphasis on gold

These and other microbial biotechnology projects with their respective budgets have been compiled in the Microbial Biotechnology for National Development Document.

5.6. COMMERCIALIZATION

5.6.1 GAEC Veterinary Clinic

The GAEC Veterinary Clinic continued to render service to owners of pets and domestic animals in the neigbourhood for minimum fees. Between June and December, a total of 483 animals were treated, an average of 69 animals per month.

Constraints

The major constraints faced by the clinic, listed in order of priority, are:

1. Lack of Space and telephone
2. Lack of storage facility for vaccines
3. No running tap water
4. No microscope and reagents for laboratory diagnosis

Recommendations

The clinic is presently in a single room. It is recommended that the whole building housing the clinic should immediately be converted into the clinic. This will allow for the provision of a Consulting Room, Treatment Room, a Pharmacy and Reception. Such arrangement will enhance the status of the Commission.

5.6.2 BNARI Research Farm

Produce from research activities including plantain and pineapples were sold to generate income. Additionally, plantlets of plantain and banana have also been sold to some farmers.

5.7 PHYSICAL DEVELOPMENT

There were no major infrastructural development projects in the Institute during the year.

5.8 HUMAN RESOURCE DEVELOPMENT

5.8.1 Training

Mr. A. Y. Antwi, Administrative Assistant, completed a Post Diploma Course at the University of Ghana, Legon. He was awarded a B.Sc. Degree in Public Administration in May, 2001.

Mr. W. A. Gyamera, Technician, was awarded a Diploma in Post Harvest Technology in May, 2001 after completing a course of study at the University of Ghana, Legon.

Mr. Ebenezer A. Ewusie, Technician, was admitted at the University of Cape Coast on 17th September, 2001 to pursue a two-year post-diploma degree-awarding programme. He was granted study leave with sponsorship for two years.

Mr. Samuel Odei, Clerk Gd. 1, gained admission to pursue a two year Diploma in Business Studies at the Institute of Professional Studies (IPS) in August, 2001.

Mrs. Juliana Omari, Senior Clerk, took the Stenographer Secretary and Private Secretary Examinations in June and December 2001respectively. She was successful in the examination taken in June. The results for the one taken in December have not been released yet.

Mr. Alex K. Asumeng, Technician, completed a three-year programme in Higher National Diploma in Microbiology at the University of Ghana in August 2001. He has since returned to post.

Mr. David Bansa, Scientific Officer, obtained admission to pursue a Ph.D programme in Food Science at the University of Ghana in 1998. Subsequently, Mr. Bansa won an IAEA, Technical Co-operation Contract in Human Nutrition. In September 1999, he obtained approval to change the programme to Ph.D in Nutrition with the condition that he passed all core courses in Nutrition before embarking on the research itself. However, the University granted him permission to suspend the course work to enable him start the field work of the TC (which is the focus of the Ph.D programme) because it was time bound and had to be completed within 1999-2000. Mr. Bansa intends to resume course work in the first semester of 2002/2003 academic year and present his thesis during the 2003/2004 academic year.

Prof. Mrs. Victoria Appiah, Principal Scientific Officer, submitted her thesis entitled "The use of ionizing radiation from Cobalt-60 gamma source in controlling mouldiness in dried cocoa beans" to the University of Ghana for assessment in September 2001 for a PhD. degree.

Mr. William Srekumah, Departmental Assistant, continued with a course leading to BSc. (Administration) at the University of Ghana. He is expected to complete at the end of the 2001/2002 academic year.

Miss. Josephine B. Coleman, Senior Stenographer/Clerk, started a 3-year HND course in Secretaryship and Management at Accra Polytechnic.

5.8.2 CONFERENCES/COURSES/ SEMINARS/WORKSHOPS

Charles E. Annoh

Graduate seminar at University of Cape Coast. Presented a paper on "Inherited sterility of Lepidopterous maize stem borers for insect pest management programme in Ghana. 30 May, 2001

Delphina A. M. A. Gomez

i. 5th National Governance Workshop. AICC, Accra, Ghana. 5 – 6 June, 2001.
ii. 3rd ARPPIS/ASA Symposium, University of Ghana, Legon-Accra, Ghana, 26 – 28 November, 2001.
iii. 1st RCM of RAF/0/016 on Sustainable Energy Development for Sub-Saharan Africa. Miklin Hotel, Accra, Ghana, 26 – 30 March, 2001 (opening ceremony only)

Charles des Bordes

i. National Rabies Awareness Forum. Ebenezer Presbyterian Church, Osu, Accra; 27 June, 2001
ii. AFRA Workshop on Preparation of Public Relations Plan:, Miklin Hotel, East Legon-Accra, Ghana. 14 -18 May, 2001
iii. Ghana Veterinary Medical Association Conference and Annual General Meeting. Koforidua, Ghana. October, 2001.
iv. Seminar on Bio-Security in Livestock Production, Trade Fair Site, La-Accra, Ghana. 5 December, 2001.

H. M. Amoatey

Workshop on Biotechnology Capacity Building, IITA (Ibadan, NIGERIA): 28 – 31 May 2001.

D. K. Asare

i. College on Soil Physics. The Abdus Salem International Centre for Theoretical, Physics, Trieste, ITALY, 12 – 30 March, 2001.
ii. Workshop on Soil Systems in the Context of Climate Change. The Abdus Salem International Centre for Theoretical Physics, Trieste, ITALY, 02 – 06 April, 2001.

K. O. Ayeh

Workshop on Root and Tuber Germplasm Characterization. Plant Genetic Resources Centre, Bunso, Ghana, 04 –06 April, 2001.

Rose Boatin

13th Annual Conference of The Ghana Chemical Society. GAEC, Accra, Ghana. 11-13 October, 2001.

Josephine Nketsia-Tabiri

i. A training course on Science and Technology for Africa - Policies and Institutions to Maximize Benefits from Biotechnology, Nairobi, Kenya, 23 July - 8 November, 2001.
ii. The first Roundtable on "Africa, Science and Technology in the Age of Globalization. The African Centre for Technology Studies (ACTS), Nairobi, Kenya. 7 - 8 August, 2001.
iii. Africa Biotechnology in the Age of Globalization. The African Centre for Technology Studies (ACTS), Nairobi, Kenya. 7 November, 2001.

David Bansa

17th International Congress of Nutrition, Vienna, Austria, August 27 - 31, 2001.

Alex Owusu-Biney

i. "The Bangkok Conference on New Biotechnology Foods and Crops: Science, Safety and Society". Bangkok, Thailand. 10 - 12 July, 2001.
ii. A training course on "Science and Technology for Africa - Policies and Institutions to Maximize Benefits from Biotechnology". Nairobi, Kenya, 23 July - 8 November, 2001.
iii. The 1st Roundtable on "Africa, Science and Technology in the Age of Globalization". The African Centre for

Technology Studies (ACTS), Nairobi, Kenya, 7 - 8 August, 2001.

iv. The "Africa Biotechnology in the Age of Globalization". The African Centre for Technology Studies (ACTS) Nairobi, Kenya, 7 November, 2001

v. Communication on Biotechnology" - a training workshop on enhancing scientists communication with the Mass Media. Nairobi, Kenya, 27 - 29 November, 2001.

The Department of Food Science and Radiation of BNARI and the Radiation Technology Centre of NNRI organized Regional (AFRA) Training Workshop on Good Management Practices for Optimal Utilization of Radiation Facilities. Accra, Ghana, 1-18 May, 2001. **Prof. Mrs. Victoria Appiah** was one of the lecturers for this workshop. **A. Owusu-Biney, A. Adu-Gyamfi** and **J. K. Apatey** were participants. A number of the scientific staff of the Department of Food Science and Radiation Processing participated as observers.

5.9 EXPERT MISSIONS

The institute did not host any experts this year.

5.10. PUBLICATIONS

5.10.1 Papers published in refereed Journals

1. **Annoh, C. E., Adabie-Gomez, D. A.,** Ennison, I. and Emi-Reynolds, G. (2000) Radio-sterilization effects on adult males of *Glosssina tachinoides* exposed to different doses of Gamma Irradiation: *Journal of Ghana Science Association (Special Edition)* **Vol. 2, No. 3:** 193 – 199.

2. **Annoh, C. E.** and **Adabie-Gomez, D. A.** (2000) "Some Biological Characteristics of Pupae of Two Species of Lepidopterous Maize Stemborers Laboratory reared for Inherited Sterility Control Programme in Ghana. *Jn. Gh. Sc. Assoc.* **Vol. 2, No. 2**, 54 - 61.

3. **Annoh C.E.** (2001) Sterile Insect Technique - An effective tool for insect pest management. *Biotech. Ghana.* **Vol. 1, No.3:** 6 - 7.

4. **Mohammed-Alfa, M.** (2001) Improving Animal Health through Vaccine Development - A case for Recombinant Vaccines. *Biotech. Ghana,* **Vol.1. No. 3,** pp 7.

5. **Asare, D. K.,** Sammis, T. W., Dan Smeal, Hailin Zhang and D. O. Sitze (2001). Modelling an Irrigation Management Strategy for Minimising the Leaching of Atrazine. *Agricultural Water Management* **48**: 225 - 238.

6. **Amoatey, H. M., Klu, G. P. Y., Bansa,** D., Aboagye, L. M., Bennet-Lartey, S. O. & Gameagbao, D. K. (2001) African Yam Beans (*Sphenostylis stenocarpa*): A Neglected Crop in Ghana. *West African Journal of Applied Ecology*, **Vol. I**: 53 – 60.

7. **Klu, G. Y. P., Amoatey, H. M., Bansa. D.** and Kumaga, F. K. (2000). Cultivation and Use of African Yam Beans (*Sphenostylis stenocarpa*) in the Volta Region of Ghana. *Plant Genetic Resources Newsletter*, **No. 124**:13-16.

5.10.2 Scientific Papers in press or submitted for publication

Annoh, C. E., Luger, D., Barnor, H. and **Gomez, D. A.** Capability of *Glossina tachinoides* Westw. (*Diptera: Glossinidae*) males to mate and inseminate female flies in different mating ratios of SIT programme in Ghana. *Gh. Jn. Sc.* **Vol. 40** (in press).

1. **Asare D. K. and Amoatey H. M.** Potential of Crop Models for Improving and Sustaining Crop Productivity in Ghana. *Ghana Journal of Agricultural Science* Vol. 34: (in press).

2. **A. Adu-Gyamfi.** Food Irradiation: An Emerging Opportunity for African Countries. *Ghana Journal of Agricultural Science*. (submitted)

3. **A. Adu-Gyamfi.** Advancing Biotechnology for National Development: Opportunities and Challenges. *Journal of Science and Applied Technology* (Submitted)

4. **D. Bansa,** A. Lartey, **S. Timpo** and P. Asamoa-Tutu. Evaluation of Breast Milk Intake of Infants and Body Composition of Lactating Mothers using Deuterium Oxide and Fourier Transformed Infrared Spectroscopy. Paper submitted through the IAEA for review and publication.

5.10.3 Seminars/Conference Papers

1. **V. Appiah** - "Agro-Industry: A Key to National Development" Paper presented at a seminar at Faculty of Agriculture, Legon.

2. **J. N. Tabiri** - "Fighting poverty in Ghana through sustainable agriculture - the role of biotechnology". Paper presented at a Regional Workshop under the theme "Africa Biotechnology in the Age of Globalization". Nairobi-Kenya 7th November, 2001.

3. **Owusu-Biney, A.** and Nketsia-Tabiri (2001) *Development of Ghana Biotechnology Policy - Some Policy Considerations.* A paper presented at a Regional Workshop (held in Nairobi Kenya) under the theme "Africa Biotechnology in the Age of Globalization" on 7th November, 2001.

5. 10.4 Papers Presented at GAEC Weekly Seminars

Annoh, C. (29-05-2001) Inherited Sterility of Lepidopterous Maize stem-borer for integrated pest management programme in Ghana.

Adabie-Gomez, D.A. (17-07-2001) Ghana Uniting against Corruption – Policy, Strategies and Action plan.

Gomda. Y. M. (14-08-2001) Renal Excretion of water and electrolytes by Sedentary horses in Relationship with Sodium intake".

DesBordes, C.K. (30-10-2001) Cloning as a tool in Animal Reproduction.

Kufe, F. (30-10-2001) Rabies and its Zoonotic Importance.

Mohammed-Alfa, M. (30-11-2001) Anthrax - A disease and A weapon

Gbedemah, C.M. (29-05-2001) World Biosafety Protocol – An Assessment by of BNARI.

Appiah, Victoria (29-05-2001) The Contribution of BNARI to National Development. University of Ghana, Legon.

Owusu-Biney, A. (29-05-2001) Genetically Modified Foods in Ghana: An overview

Owusu-Biney, A. and Nketsia-Tabiri, J. (11-12-2002) Development of Ghana's Biotechnology Policy Framework: Some Policy Consideration

5.10.5 Public Educational Programme (Radio Talk Shows)

Some members of the Institute participated in Radio Talk Shows on Science and

Technology Programmes on "Setting the Agenda for the 21st Century".

Date	Radio Station	Topic of Discussion/ Participants
22nd Nov. 2001	Choice FM Radio	Biotechnology Policy and Developments in Ghana and worldwide" *Alex Owusu-Biney and Josephine Nketsia-Tabiri*
29th Nov. 2001	Choice FM Radio	Tsetse and Trypanosomiasis Problem in Ghana *D. A. Gomez & C. E. Annoh*
30th Nov. 2001	GBC Radio 2	Science and Technology, the New Direction for Research Institutions *C. E. Annoh & D. A. Gomez*
12th Dec. 2001	GBC Radio 2	Positive uses of Atomic Energy in the Field of Agriculture *D. A. Gomez & C. E. Annoh*

5.11 CONSTRAINTS/PROBLEMS

Inadequate funding continues to be the major constraint to research. Lack of funds to carry out the planned activities of the various projects, has caused some of the projects to be suspended.

Space is still a problem in the Institute. The Tissue Culture Laboratory is still not completed and this is hampering both research and commercialization.

Frequent power outage and break in water supply do not only cause a set back to research but also present an enormous economic loss since some of the experiments have to be repeated.

The breakdown of internet facility at the BNARI Directorate continued to be a set back for communication and research. In view of the fact that the internet is not only a fast means of communication but also an important source of reference, it is imperative that measures are taken to ensure its efficient and sustainable management.

5.12. PROJECTIONS

- It is the responsibility of the Commission, as a matter of urgency, to help the Institute to (a) complete the Tissue Culture Building for commercial production of planting materials for farmers and (b) to establish a Molecular Biology Laboratory to promote the study of Molecular Biology and commercial production of Recombinant DNA vaccines.

- To complete work on the systematic mapping survey of forage and animal tissue and recommend appropriate ways and means of combating mineral deficiencies and excesses through strategic supplementation feeding for various regions of Ghana.

- To step up the mass rearing of tsetse flies and carry out the pilot field trials of the SIT to control tsetse flies in one of the priority areas in the northern region of Ghana.

- To establish the prevalence of bovine TB in human TB cases and make the necessary recommendations to the Government.

- Complete studies on the anti-helminthes and recommend cheaper and more potent de-wormers for pet owners.

- To complete some of the on-going projects and start the new projects that have funding.

- Some funds will be sourced to enable the Institute carry out commercialization studies on irradiated yams and cowpeas

and public education on irradiation processing technology.

- To start the construction of the Biotechnology Laboratory Phase II which will provide space for research and development in the field of Animal and Insect Biotechnology and Food Science and Radiation Processing.

- Discussions with private commercial mushroom producers will continue with the hope to engaging them in the use of irradiation for the sterilization of the substrates for mushroom production and subsequent generation of income.

5.13 STAFF LIST

No.	Department/Name	Qualification	Position/Rank
	Administration		
1.	Prof. G. Y. P. Klu	BSc. (Hons) Biology, MSc, PhD	Prin. Sci. Officer (DIRECTOR)
2.	Ms E. B. Tamakloe	BA, MA	Snr. Adm. Officer
3.	Mr. A. Y. Antwi	Dip. Public Admin.	Adm. Assistant
4.	Mrs. Juliana Omari	GCE "O" Level, NACVET	Clerk Typist
5.	Ms. Comfort Mensah	NVTI, Govt. Sec. Gd. II	Clerk Typist Gd. I
6.	Mr. Samuel Odei	GCE "O" Level	Clerk Gd. II
	Scientific Support Service		
1.	Mr. Samuel Timpo	BSc., MPhil.	Assist. Sci. Officer
	Department of Animal Science		
	Scientific staff		
1.	Dr. Mrs. D. Adabie-Gomez	BSc. (Hons) Biology, MSc, PhD (Entomology)	Snr. Sci. Officer (HEAD)
2.	Mr. Charles Annoh	BSc, MSc	Sci. Officer
3.	Dr. Charles K. desBordes	BSc, DVM, MVSc	Sci. Officer
4.	Dr. Yahuza Gomda	MVSc, PhD	Sci. Officer
5.	Dr. M. Mohammed-Alfa	DVM, MVSc, PhD	Sci. Officer
6.	Dr. Franklin Kufe	DVM, MSc	Sci. Officer
7.	Mr. Ebenezer Ato Ewusie	Dip. Lab.Tech.	Snr. Technician
8.	Mr. Godfrey Damnyag	Cert. Vet. Tech.	Technician
9.	Mr. Albert Nkumsah	GCE "O" Level	Tech. Assistant Gd. I
10.	Mr. Charles Asante	GCE "O" Level	Tech. Assistant Gd. I
	Office Staff		
11.	Mr. Frederick Abruquah	GCE "O" Level	Deptl. Assistant Gd. II
12.	Ms. Sadia Moro	NVTI	Clerk/Typist
	Field/Laboratory Staff		
13.	Mr. Reinfred Aballey	MSLC	Laboratory Assistant
14.	Mr. Abraham Danso	MSLC.Livestock Prod. Cert	Animal Keeper
15.	Mr. Moses Asamoah	MSLC. Livestock Prod. Cert	Animal Keeper

Department of Food Science and Radiation Processing

Scientific staff

1.	Prof. Mrs. Victoria Appiah	BSc.(Hons). MSc	Prin. Sci. Officer (HEAD)
2.	Prof. Josephine Nketsia-Tabiri	BSc, MPhil. MSc. PhD	Prin. Sci. Officer
3.	Dr. Mrs. Rose Boatin	BSc, MSc, PhD.	Sci. Officer
4.	Mr. Charles Gbedemah	BSc, MPhil.	Sci. Officer
5.	Mr. David Bansa	BSc. MPhil.	Sci. Officer
6.	Mr. Alex Owusu-Biney	BSc. MPhil.	Sci. Officer
7.	Mr. Abraham Adu-Gyamfi	BSc. MPhil.	Sci. Officer
8.	Mr. Alexander P. E. Yawson	BSc. MPhil.	Sci. Officer
9.	Mrs. Stella Aniapam-Nkansah	BSc.	Asst. Sci. Officer
10.	Mr. C. F. S. Edmundson	GCE "O" Level	Chief Technician
11.	Mr. Emmanuel Akolmolga	Dip Microbiol., HND	Prin. Technician
12.	Mr. Titus Vuore	Dip. Lab. Tech.	Snr. Technician
13.	Mr. John Apatey	Dip. Agric.	Snr. Technician
14.	Mr. Tahiru Mahami	Cert Vet Tech	Technician
15.	Mr. John Bosco Adom Mensah	Gen. Cert. (Agric)	Asst. Technician
16.	Mr. Gideon Awuku	Sc. Lab. Tech. Cert. P.I	Asst. Technician
17.	Mr. McDonald Akramah	GCE "O" Level	Deptl. Assistant

Office Staff

18.	Ms. Josephine Bright Coleman	Steno. Sec (NACVET)	Snr. Steno/Clerk
19.	Mrs. Beatrice Bayala	SSCE	Clerk/Typist
20.	Mr. William Srekumah*	GCE "O" and "A" Levels	Deptl. Assistant

Department of Plant and Soil Sciences

Scientific Staff

1.	Dr. H.M. Amoatey	BSc (Hons) Agric. MPhil. PhD	Snr. Sci. Officer (Head)
2.	Dr. Daniel K. Asare	BSc (Hons) Agric. MSc. PhD	Sci. Officer
3.	Mrs. Vivian Oduro	BSc (Hons) Agric MPhil.	Sci. Officer
4.	Mr. Kwodwo Owusu-Ayeh	BSc. MSc	Sci. Officer
5.	Mr. Kenneth E. Danso*	BSc. MPhil	Sci. Officer
6.	Ms. Yvonne Lokko*	BSc. MPhil	Sci. Officer
7.	Ms. Gertrude Torto *	BSc. MSc	Sci. Officer
8.	Mr. Ernest Dinku	HND	Chief Technician
9.	Mr. Marcus Quaynor-Addy	HND	Prin. Technician
10.	Mr. Alex. K. Asumeng	HND	Technician
11.	Mr. Wilson Gyamerah	Dip. Agric.	Technician
12.	Mr. Betrand Quaye	Cert. Agric.	Technician
13.	Mr. Christian Akama	Cert. Agric.	Technician

Office Staff

14. Ms. Elizabeth Amosah	NVTI, GCE "O" Level	Senior Clerk
15. Mr. Mathew De-Graft-Mensah	GCE "O" Level	Deptl. Assist. Gd.II

Production Staff

16. Mr. Samuel Obuobi	SSCE	Tech Assistant Gd. II
17. Mr. Kwame Asare	SSCE	Tech. Assistant Gd. II
18. Mr. Emmanuel Ofosu	MSLC	Dept. Assistant Gd.II
19. Mr. Seth Asare-Bediako	SSCE	Production Assistant
20. Mr. Mawuli John Torsu	SSCE	Production Assistant

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22. Mr. Yaw Boadu	MSLC	Snr. Gardener
23. Mr. Zacharia Bayor	MSLC	Snr. Gardener
24. Mr. Azure Akologo	MSLC	Gardener Gd.II
25. Mr. Abraham Tetteh	MSLC	Farm Hand
26. Mr. Samuel Odonkor	MSLC	Farm Hand
27. Mr. Nii Otu-Lartey	MSLC	Farm Hand
28. Mr. Kennedy Tetteh	MSLC	Farm Hand
29. Mr. Edward Aglago	MSLC	Farm Hand

* On Study Leave Abroad

6. MEMBERS OF THE DOCUMENTATION AND PUBLICATION COMMITTEE

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Dr. Harry M. Amoatey (BNARI)		Member
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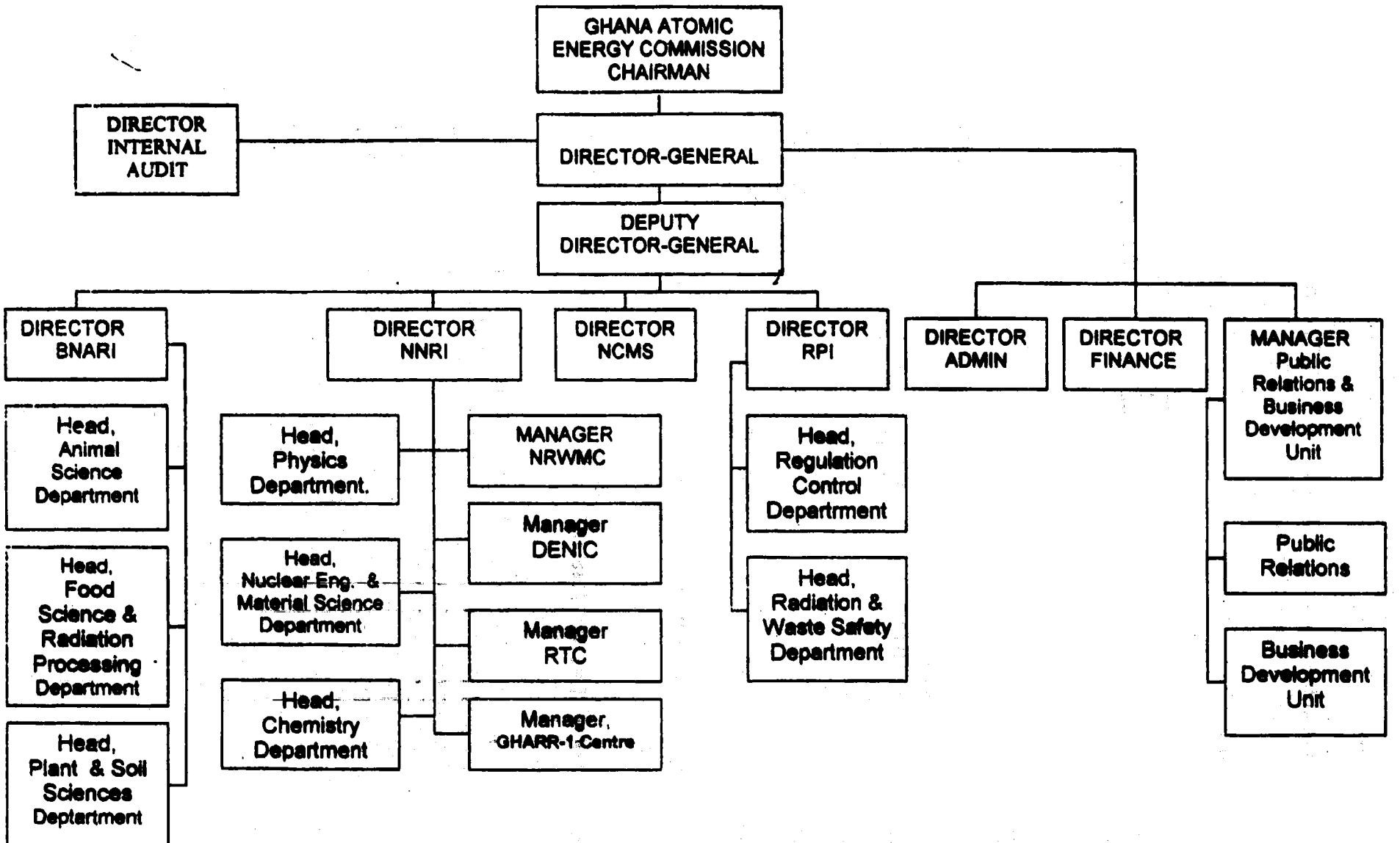
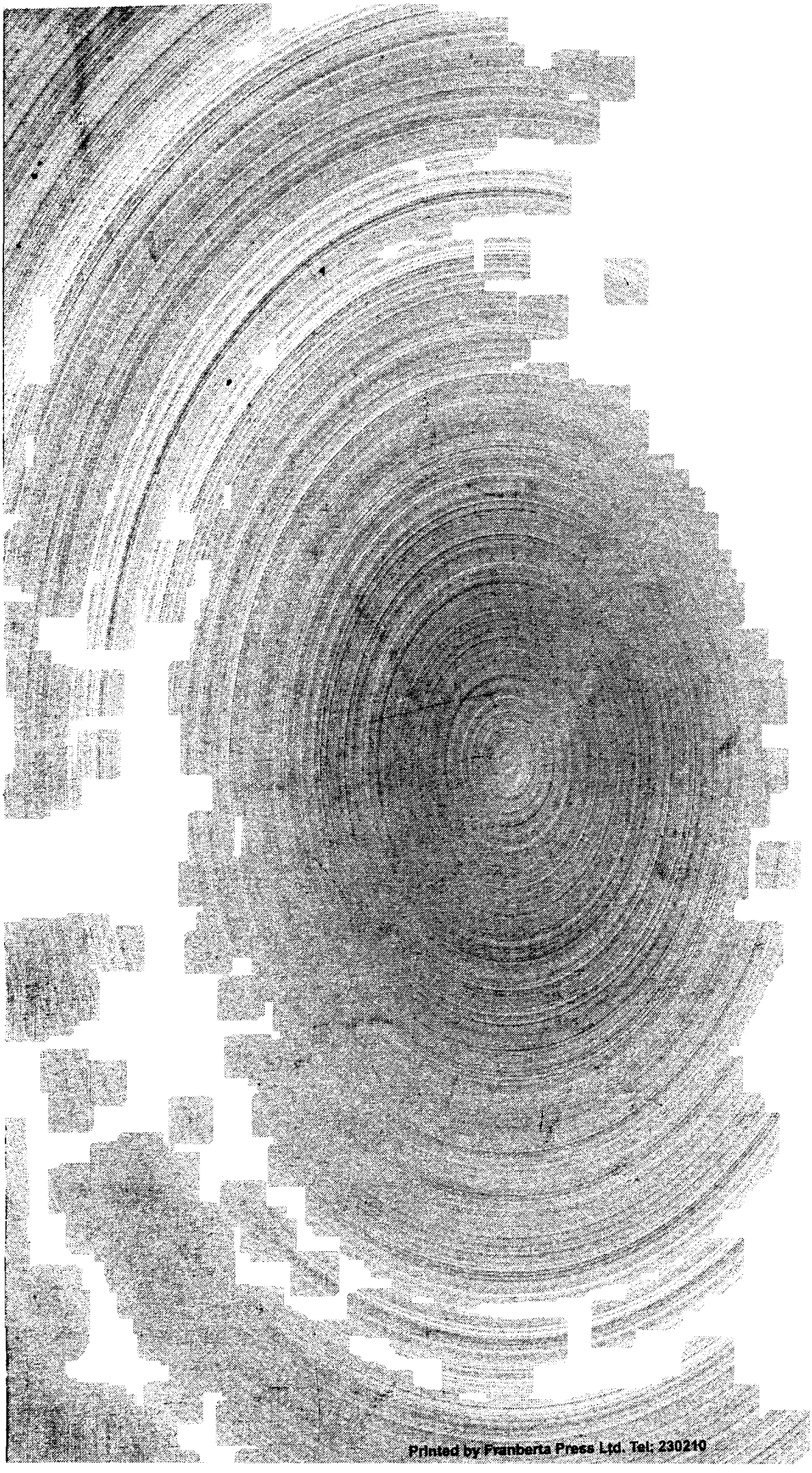
ORGANISATIONAL STRUCTURE OF THE GHANA ATOMIC ENERGY COMMISSION



NB. The organogram shows the reporting lines and not necesarily the levels of authority.



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