

CSIR WATER RESEARCH INSTITUTE



SUMMARY

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1.0 INTRODUCTION

CSIR Water Research Institute is one of the 13 institutes of the Council for Scientific and Industrial Research (CSIR). Its mandate is to conduct research into water and related resources through the generation and provision of scientific information, strategies and services towards the rational development, utilisation and management of water resources of Ghana in support of socio-economic advancement of the country. The key objectives of the Institute are:

- To generate, develop and transfer appropriate technologies, information, and services for sustainable development, utilization and management of surface water resources,
- To generate, process and disseminate information on the availability of groundwater, rates and volumes to be abstracted for various uses as well as the reliability and sustainability of its recharge,
- To generate, process and disseminate water and waste water quality information to end users,
- To enhance public health status through sound environmental management and water pollution control strategies,
- To increase local fish production through participatory research and technology transfer in aquaculture and sustainable management strategies in inland and coastal waters of Ghana, and

To undertake commercialisation of research and development activities through consultancy and advisory services and the provision of water resources information, documentation and technical support services.

The mandate of the Institute is realized through the research and development activities of eight (8) Divisions namely Groundwater Division, Surface Water Division, Environmental Chemistry Division, Environmental Biology and Health Division, Fishery Division, Commercialization and Information Division, Administration Division and Finance Division. Currently, the Institute has its main offices in Accra and branches in Tamale and Akosombo.

Beneficiaries of the Institute's research and development activities include:

- Afariwa Estates Ltd.
- Agricultural Extension Officers
- Agro-forestry and Integrated Water Management Specialists
- AngloGold Ashanti Ghana Ltd.
- Association of Ghana Industries
- Bamson Company Ltd.
- Barry Callebaut Ghana Ltd.
- Benso Oil Palm Plantations Ltd.
- Bioland Company Ltd.
- Borehole Drilling Companies
- Bottled and Sachet Water Producers
- Cadbury Ghana Ltd.
- Catholic Relief Service
- CIDA-HAP
- Cob-A Industries Ltd.
- Coca-Cola Ghana Ltd.
- Cocoa Processing Company Ltd.
- Community Water and Sanitation Agency
- CSIR-OPRI
- Diplomatic Missions

- District and Municipal Assemblies
- Environmental Protection Agency
- Environmental Solutions
- Fish farmers
- Fisheries Commission
- Food and Drug Board
- Food and Beverage Industries
- GAFCO
- Ghana National Commission for UNESCO
- Ghana Oil Palm Development Company
- Ghana Water Company Ltd.
- Ghana Wildlife Division of the Forestry Commission
- Glowa Volta Project of ZEF
- Golden Hotel Ltd.
- Golden Tulip Hotel
- Goldfields Ghana Ltd.
- Groundwater Development/Management Consultants
- International Water Management Institute
- Irrigation Development Authority
- Jei River Farms Ltd.
- Koajay Co. Ltd.
- Major & Co Ltd.
- Minerals Commission
- Ministry of Environment, Science and Technology
- Ministry of Fisheries
- Ministry of Food and Agriculture
- Ministry of Health
- National Disaster Management Organisation
- National Onchocerciasis Secretariat
- Newmont Ghana Gold Ltd
- Nkulenu Industries
- Non-Governmental Organisations
- Plan Ghana Limited
- Phyto-Riker Pharmaceutical Ltd.
- Pioneer Food Cannery Ltd.
- Polykraft (Ghana) Ltd.
- Polytechnics
- Public and Private Universities
- Rice Farmers
- Rotary Club
- Senior High Schools
- Tesano Sports Club
- The Bible College of Ghana
- Twifo Oil Palm Plantations Ltd.
- UNESCO
- Vicco Ventures Ltd.
- Volta Lake Transport Company
- Volta River Authority
- Water Resources Commission
- West Africa Rice Development Agency

- World Vision
- WRIS/DANIDA

2.0 MAJOR RESEARCH AND DEVELOPMENT ACTIVITIES

For the year 2010, summaries of the research activities of the five (5) technical Divisions of the Institute included the following:

2.1 SURFACE WATER DIVISION

2.1.1 Hydro-Meteorological Database Management

The hydro-meteorological data base management system was instituted by the CSIR Water Research Institute (WRI) to generate and provide hydro-meteorological data from the Institute's synoptic station (05° 35705N, 00° 11105W; altitude 45.72 m) to support the Institute's research activities and that of other research agencies. The main parameters measured and compiled in the reporting year were rainfall, temperature, evaporation, sunshine duration and wind-run.

Evaporation was generally higher than rainfall. Comparatively, the total annual rainfall for the year was 815 mm while the highest total annual rainfall since the inception of the station (1976 – 2010) was 1284 mm in 2002.

2.1.2 Climate Change Effects on Hydrology and Water Resources and Adaptation Strategies in Ghana

This project focused on the impact of climate change on watershed hydrology and surface water resources in Ghana. The main objective of this project was to generate scientifically based impact-specific information that could be used to directly inform the preparation of local and national action plans on climate change adaptation in Ghana.

In the year under review, SWAT was successfully set-up, calibrated and validated for the White Volta and Pra River basins using measured streamflow data for the stream gauges at Nawuni (White Volta basin) and Twifo Praso (Pra basin). Monthly calibration and validation showed that the R^2 and NSE were greater than 0.70 and 0.68 respectively, for the two basins. Under the assumption of 100 % water usage in the two basins, the White Volta basin would experience water stress before 2020 and water scarcity after 2020, with or without climate change. However, with the effects of climate change, the basin would experience absolute scarcity condition before 2050. With the current water stress condition of the Pra basin, it is expected to aggravate to water scarcity conditions before 2020, with or without climate change. It was recommended that integrated water resources management (IWRM) is needed to ensure a holistic and sustainable management and use of water resources.

2.1.3 Groundwater in Sub-Saharan Africa: Implications for Food Security and Livelihood

The overall goal of the project was to enhance the role of groundwater in the provision of improved food security and livelihood in Sub-Saharan Africa and particularly, in AGRA countries including Ghana.

Activities undertaken during the reporting year included selection of groundwater based irrigation sites in the Upper East Region, baseline study, hydrogeological surveys and preparation of country reports on groundwater status in Ghana, Burkina Faso, Mali and Niger. The study showed that groundwater availability in many places in Ghana and Burkina Faso is attributed to fractures, faults and weathering of the rocks and aquifer yields are generally low (average of 2 m³/h). However, high yields of 100 m³/h or more are found in the Continental Terminal aquifers in northwestern Burkina Faso and in the Coastal aquifers in southeastern Ghana.

2.1.4 Eco-Health Approach to the Control of Onchocerciasis in the Volta Basin of Ghana

The goal of this project was to study how the effects of onchocerciasis could be reduced in Ghana through sustainable community-directed environmental management in ivermectin-resistant areas.

The scope of work in the reporting year included field visits to hydro-meteorological observatory stations in the Pru and Black Volta basins, analysis of trends in extreme climate events, pre-processing of various data for modeling, initial set up of the hydrological model SWAT (Soil and Water Assessment Tool) and training of Graduate students in hydrological modeling. Preliminary results for the Atebubu climate station showed increasing trend in the total annual precipitation, maximum of the daily maximum temperature, minimum of the daily maximum temperature, maximum of the daily minimum temperature and minimum of the daily minimum temperature. With the exception of the annual precipitation, all the increases obtained were significant at 95 % confidence level.

2.1.5 Rethinking Water Storage for Climate Change Adaptation in Sub-Saharan Africa

As part of Adaptation of African Agriculture to Climate Change program, this study was initiated to improve the livelihood and increase resilience of the rural poor in Sub-Saharan Africa (SSA) vulnerable to climate change risks through better water storage mechanisms, improved investments and institutional support. Activities carried out in the year under review included field surveys on efficiency and performance of water storage systems at Vea in the Upper East Region, Golinga in the Northern Region and Sata in the Ashanti Region of Ghana.

The commonest water storage systems identified were dams, boreholes, hand-dug wells and rainwater harvesting systems. The available storage systems were generally inadequate, poorly managed and needed urgent rehabilitation. The status of the systems indicated that they lacked the necessary resilience to population increase and impacts of environmental and climate change. It was recommended that external financial assistance would be required to adequately handle broken down pumps and dilapidated dam structures and canals so as to increase the resilience of the systems to both human and environmental change impacts.

2.1.6 Update on Flood Phenomenon in Ghana

The goal of the study was to enable decision makers prevent, mitigate and manage flood disasters in Ghana to minimize their potential impacts on life and property. During the reporting year, hydrometeorology and hydrological data were collected and analysed. Poor and/or lack of drainage systems, building in water courses, siltation and improper waste (especially plastic waste) management were identified as the primarily causes of flood in the capital of Ghana. Estimations from the extreme value distribution shows that there was a 100 % chance that streamflows (floods) with magnitudes $650.6 \text{ m}^3/\text{s}$, $296.4 \text{ m}^3/\text{s}$ and $36.50 \text{ m}^3/\text{s}$ would occur any day during the year in the Volta, South Western and the Coastal river systems, respectively. Similarly, streamflow of magnitudes $3529 \text{ m}^3/\text{s}$, $561.0 \text{ m}^3/\text{s}$ and $105.0 \text{ m}^3/\text{s}$ could occur once during any day in 10 years in the Volta, South Western and Coastal river systems, respectively.

2.2 GROUNDWATER DIVISION

2.2.1 Isotope Techniques for Groundwater Assessment of the Central Region

The objective of this study was to solve groundwater problems in the Central Region using integrated conventional and isotope techniques. Isotope techniques in ground and surface water studies could lead to identifying the sources of major ions in these waters and delineate

high chloride areas which are major problems in the Central Region. During the year, water samples from selected water bodies such as rivers and boreholes were periodically collected and analyzed. The results indicated that groundwater in the area is weakly acidic with mean pH of 5.83 pH units. The principal hydrochemical facies observed were Na-Cl, Na-Cl-HCO₃ and Na-HCO₃-Cl water types.

2.2.2 Groundwater Monitoring of Northern Ghana

This project started in 2005 to assess the groundwater of the three (3) Northern Regions of Ghana. During the year, 37 monitoring boreholes were visited in the dry and wet seasons to download the recorded groundwater fluctuation data. Samples of water were also taken from all the boreholes for physico-chemical analysis. The general observation was that groundwater levels have remained unchanged despite the general perception that they should rather decrease as a result of overexploitation, over-pumping and climate change impact over the years and this might be due to the deep aquifers within the study area. There was an increase in groundwater conductivity and total dissolved solids during the raining season and this could be the result of surface water infiltration into the groundwater system.

2.2.3 Geo-logging and Diver Installation of 15 Newly-Drilled Monitoring Boreholes

The purpose of the project was to obtain sub-surface information related to log-stratigraphy of the rocks penetrated during drilling and to determine the magnitude and vertical variation of groundwater salinity in the different rock types underlying the study area. Activities carried out included borehole logging and diver installation. The data obtained was analysed using 'Viewlog' software. The results showed that in order to obtain potable water, the depths of boreholes drilled through shale, mudstone and siltstone rocks should not exceed 60 m.

2.3 ENVIRONMENTAL CHEMISTRY DIVISION

2.3.1 Industrial Water and Wastewater Studies

The study was aimed at generating relevant and comprehensive data on raw and spent water which could be used to implement rational water utilization and management programmes in the Cocoa Processing Company Limited (PORTEM), Cadbury Ghana Limited, Kasapreko Ghana Limited, Bamson Company Limited, Pioneer Food Cannery, Phyto-Riker Pharmaceuticals and Golden Tulip Hotel.

In the reporting year, water samples, raw and treated effluent samples were collected on monthly and sometimes on quarterly basis and analyzed. The data produced was used to design treatment plants in some of the industries such as the Cocoa Processing Company Limited. The data was also used for developing environmental management plans for the industries.

2.3.2 Ground and Surface Water Quality Assessment

The objective of the study was to verify whether the activities of Goldfields Ghana Limited (GGL) have any negative impact on the communities' water resources. It was also to determine the effects of mining operations on the quality of surface waters, sediments and groundwater through drilled observation wells for monitoring.

In the reporting year, water and sediment samples were taken from 26 stream sampling sites; 31 boreholes; 21 treated seepage and leachate water sites; 35 Wells for potable use in Samanhu, Atuabo, Huniso and Esuman; and 30 Wells at Tebe, Abekoase and Pepesa. These samples were analysed using standard methodologies.

Results obtained from the surface water samples showed that the ionic dominance pattern observed in the Tarkwa area, Na > K > Ca > Mg : HCO₃ > SO₄ > Cl, did not conform to the ionic dominance pattern of Ca > Mg > Na > K and HCO₃ > SO₄ > Cl for freshwater. The

high iron levels recorded could be due to the geology of the area. Analysis of the groundwater indicated that the pH values for 40 of the wells out of the 47 sampled fell below the WHO minimum limit of 6.5 pH units and this could be attributed to the geology of the area. Depending on environmental conditions, the acidic waters could leach trace metals from their surroundings. The nitrate-nitrogen concentrations in the boreholes gave no indication of contamination from the external environment and there were no adverse effects with respect to heap leaching in terms of contaminating the groundwater in the area.

It was recommended that communities living within the concession of Goldfields Ghana Limited should be educated to avoid pollution of surface waters (streams) through the impact of human activities.

2.3.3 Surface Water Quality Monitoring and Assessment of the Volta, Southwestern and Coastal River Systems

The project began in the reporting year to develop an efficient and effective management system for sustainable development of Ghana's water resources to ensure full socio-economic benefits for present and future generations. The scope of work included collection of water, sediment and fish samples for physico-chemical, metals, sediment quality and bacteriological analysis. The Water Quality Index classification of the waters indicated that most of the water bodies were in Class II, the "fairly good quality" state, but with seasonal variations in quality states. The overall characteristics of the water samples indicated that, the Volta River System was comparatively less polluted than the Southwestern and the Coastal River Systems.

2.3.4 Three Districts Water Supply Project

This study was aimed at assessing the quality and suitability of treated water for potable use in the Dangme East, Dangme West and North Tongu Districts. The scope of work included collection of water samples, laboratory analysis, data interpretation and preparation and submission of reports. The results of the physico-chemical and bacteriological examinations of the water samples indicated that the water from the stand pipes were suitable for domestic purposes based on WHO guideline and Ghana standards.

2.3.5 Limnological Study of Three Coastal Water Supply Reservoirs in Ghana

The study started in 2007 to monitor temporal changes in the water quality of the Inchaban, Brimsu and Weija reservoirs that supply water to the Sekondi, Cape Coast and Accra, respectively. During the reporting year, water samples were collected hourly in the day at the intake points of the reservoirs during the dry season and analysed using standard methodologies. The study showed that the pH increased considerably in the late mornings and afternoons but decreased when sun was approaching and this could be due to changes in temperature of the reservoirs.

2.3.6 Sustainable Cage Aquaculture Development on the Volta Lake

This collaborative study with the Fisheries Commission started in 2009 to estimate the carrying capacity of the Volta Lake in relation to cage and pen aquaculture development. It was also aimed at assessing the socio-economic impact of cage aquaculture development in the Volta Lake and providing guidelines for sustainable cage aquaculture development in Ghana.

In the reporting year, water samples for physico-chemical analysis were collected from fifteen (15) locations on the Volta Lake with clusters of fish cages or pens including the gorge area, Atimpoku, Akuse and Sogakope.

The levels of trace metals were generally low and did not present any threat to biota. The observed low ionic content of the Lake is good for aquatic ecosystem use. Nutrient

concentrations were generally low in areas with the fish cages except in the lower Volta area. Although, there were no immediate detectable impacts of fish farming on water quality of the Lake, the study recommended the need for regular water quality monitoring and the need to estimate the carrying capacity of the Lake to develop good water management practices to ensure sustainable use of the Lake.

2.3.7 Quality of Water Bodies in Mining and Non-Mining Areas within the Ashanti Gold Belt

The study was initiated in 2008 to assess the hydrochemical processes influencing water bodies and to identify and characterise the trace metal levels in water bodies within the Ashanti Gold Belt. A total of 113 samples were collected from boreholes, wells and streams in Obuasi and some communities within the Ashanti Gold Belt during the dry and wet seasons between 2008 and 2010.

The study showed that the chemical constituents of the study area were generally low with relative abundance of cations and anions in the order of $\text{Ca}^{+2} > \text{Na}^+ > \text{Mg}^{+2} > \text{K}^+$ and $\text{HCO}_3^- > \text{Cl}^- > \text{SO}_4^{-2} > \text{NO}_3^-$, respectively. The study also showed that, gypsum, anhydrite, calcite and dolomite dissolution were some of the processes influencing the water chemistry of the study area.

2.4 ENVIRONMENTAL BIOLOGY AND HEALTH DIVISION

The Environmental Biology and Health Division for the year 2010 dealt with the health of the individual in the use of water and from other associations with water. These included:

Regular monitoring of bottled and sachet waters for sale in the market by the Division for bacterial contamination led to improvement in sale of safe and good water in the market through recommendations given to the sachet and bottled water producers.

The assessment of quality of water for Cyanobacteria and other pathogenic organisms that are causative organisms for water borne diseases such as dysentery, cholera, typhoid, diarrhea and other gastro-enteritis continued. These assisted in the intensification of the application and enforcement of sound and safe practices that led to provision of safe and good water sources.

There was also study on the damage caused to the environment by small scale miners in many parts of the country. This has improved understanding of multiple-use of water by the communities.

There was study on methods to remove barriers to invasive plant management in Ghana in an effort to reduce the level of aquatic weeds (especially water hyacinth) infestation in our water bodies, notably the Oti arm of the Volta River. There has been general awareness of the threat of aquatic weeds in Ghana. Various control measures have been suggested to reduce the threat in the Volta River and the Abby lagoon.

There are five (5) distinct Sections making up the Division. These are Microbiology, Macro-Invertebrate, Hydrobotany, Entomology and Parasitology.

2.4.1 The Occurrence, Diversity and Ecological Attributes of the Blackfly in the River Densu Basin

This study was aimed at assessing the status of the blackfly and onchocerciasis in the River Densu Basin. In the reporting year, aquatic forms of immature simuliid were sampled from

twigs, stems, stones and trailing vegetations in the flowing sections of the River Densu and its tributaries. The samples were examined and identified.

Simulium species identified in the study were *S. unicornutum*, *S. alcocki*, *S. damnosum s.l.*, *S. adersi* and *S. cervicornutum*. The medically important species, *S. damnosum s.l.*, occurred at sites with pH range of 6.6 – 6.8 pH units, flow rate range of 1.7 – 2.1ms⁻¹ and mean dissolved oxygen levels above 60 % (>60 %) saturation. Hence, while the other species appeared to be tolerant of varying ecological characteristics of the rivers, the *S. damnosum s.l.* appeared to exhibit some sensitivity.

2.4.2 The Role of Algae and Macro-Invertebrates in the Removal of Faecal Bacteria from Domestic Wastewater Using Natural Treatment Systems and Open Waters

The objectives of the project were to assess the performance and mechanism of faecal bacteria removal from a pilot scale hybrid algal and duckweed domestic wastewater treatment system; and to assess the ability of some gastropod mollusks of medical importance to withstand some environmental stresses and their contribution to the removal of faecal bacteria from open waters.

During the reporting year, the performance of a pilot-scale hybrid duckweed and algal domestic wastewater treatment plant under tropical conditions was investigated. In addition, the response of the macro-invertebrates, *Biomphalaria pfeifferi* and *Bulinus truncatus* to salinity stress was also investigated. Laboratory experiments were also conducted to investigate the role of *Melanoides tuberculata* and *Bulinus truncatus* in the removal of faecal bacteria from a polluted river modified for providing drinking water to nearby municipalities. The results showed that invertebrates *Melanoides tuberculata* and *Bulinus truncatus* could play a role in the regulation of faecal bacteria numbers in ecosystems with significant leaf litter.

2.4.3 Management of Pulp Mulberry “*Broussonetia papyrifera*” in the River Afram Headwaters Forest Reserve, Ghana

The study was conducted to produce practical means of controlling *Broussonetia* reservoirs in Ghana in order to facilitate forest and biodiversity restoration, improve agricultural efficiency and reduce the rate of spread of the infestation.

In the reporting year, three experimental trial plots were demarcated and used for biodiversity restoration studies in the River Afram Headwaters Forest Reserve at Abofour in the Offinso South Municipality of the Ashanti Region. The study showed that although there were some coppicing on trees treated with Glyphosate or Round-up, there was no coppicing on trees treated with Spear. Frilling with the herbicide, Spear appeared to be the most effective control strategy with trees dying relatively soon after application.

2.4.4 The Impact of Collection and Disposal of Solid Wastes on the Environment and on Health: The Case of Accra Metropolitan Area

This study was conducted in the Accra metropolis to investigate the impacts of solid wastes collection and disposal on the environment and on human health. It was also aimed at examining the effectiveness of the various solid wastes management systems put in place. Water, leachate and soil samples were collected from six sampling sites over a period of six months and analysed for coliform bacteria, helminthes or helminth eggs.

The total and faecal coliforms concentrations in the water samples ranged from 1.0 – 232.0 x 10⁴ cfu/100 ml and 0.2 – 22.4 x 10⁴ cfu/100 ml, respectively. The level of concentration of coliform bacteria could pose a major risk to human health and the environment. The social survey revealed that the increasing solid wastes generation in the Accra metropolis has not been accompanied with adequate sanitation facilities and management programmes. Some

key problems identified included indiscriminate dumping and difficulties in the acquisition of suitable disposal sites.

To ensure effective and efficient solid wastes management in the Accra metropolis, some recommendations given were: the Environmental Health Directorate of the AMA should draw up a health education plan every year to educate the people on safe methods of wastes disposal; and policies on private participation in solid wastes management must be redesigned and implemented to address the solid wastes management issues within the study area.

2.4.5 Water Supply and Sanitation and their Effects on the Health Status of the People of Chorkor in the Ablekuma Sub-Metro of the Accra Metropolitan Assembly

This study was undertaken to identify the present water supply and sanitation situation and their effects on the health status of the people of Chorkor. In the reporting year, water samples were collected at vantage points from the distribution pipelines and analyzed. Social survey was also undertaken to assess the sanitary condition of the study area.

The analyses revealed that the physical and chemical parameters of most of the water sources in the community were within the WHO and Ghana standards with few sources having values that were quite high. However, the microbiological parameters of the water sources extremely exceeded the WHO and Ghana standards for permissible limits of Total Coliform, Faecal Coliform and Total Heterotrophic Bacteria for potable water. Practices such as poor sanitary conditions, burst and leaked pipelines, illegal connections and distribution pipelines laid through wastewater channels were responsible for the presence of *Vibrio cholera*, *Salmonella typhi*, diarrhoea and dysentery and malaria within the area and its catchments.

Some recommendations made were: there should be regular sanitary inspection by the Sub-metropolitan authorities to keep Chorkor clean; thorough microbiological examination of water from homes and water vendors should be conducted to ensure the safeness of drinking water; and there should be routine monitoring of distribution pipelines by Ghana Water Company Limited and its operating agencies to check on illegal connections, burst and leaking pipes.

2.4.6 Cattle-Grazing on Playing Fields: Source of Environmental Contamination to School Children in the Greater Accra Region

The aim of this study was to investigate the presence of pathogenic organisms in cattle dung and grass from playing fields used for cattle grazing. Two playing fields used for cattle grazing and one other playing field not used for cattle grazing (control sample) were selected. Cattle dung and grass samples from the fields and finger/hand swab samples from children who played on the fields were collected on monthly basis in the dry and wet seasons for six (6) months and examined bacteriologically and for helminth.

The presence of *Salmonella*, *E. coli*, *Ascaris*, *Strongyloides* and Hookworm in the cattle dung was indication that other pathogens such as *Clostridia*, *Shigella*, *Giardia* and other helminths could be present in the dung. These were transferred onto the grass and were subsequently picked on the fingers/hands of the children who played on the fields.

Recommendations made included educating the cattle owners/farmers, schools and community leaders who have allowed their premises to be used for cattle grazing and the general public on the health hazards of their activities to the society; laws against cattle grazing in cities/towns should be revisited and enforced; and there should be further research to identify the other species of the pathogens present in cattle dung.

2.4.7 The Impact of Doxycycline Treatment on Transmission of *Onchocerca volvulus* in Communities Showing Sub-Optimal Response to Ivermectin Treatment

This study was aimed at determining whether the treatment of Ivermectin (IVM) sub-optimal responders with doxycycline would significantly impact on onchocerciasis transmission. The specific objectives were to assess vector abundance, densities and the man biting rate of *S. damnosum* in the study areas; determine the vector infection rates and transmission potential following treatment of sub-optimal responders with doxycycline; and assess the reduction in transmission of onchocerciasis following doxycycline treatment and determine whether possible disease recrudescence can be prevented using doxycycline.

Thirteen (13) onchocerciasis endemic communities showing sub-optimal response to IVM treatment were selected from Yeji, Kintampo and Tain districts of the Brong-Ahafo Region. A total of 3,790 and 14,555 blackflies were collected during the dry and wet seasons, respectively. They were identified and dissected on the same day to determine the fly parity and presence of the parasite larvae of *O. volvulus*.

Analyses of the entomological data collected before and after the doxycycline trial showed that the interventions with doxycycline had significant impact on onchocerciasis transmission in communities showing sub-optimal responses to IVM treatment. It was recommended that in endemic communities where onchocerciasis transmission is still relatively high, individuals responding sub-optimally to IVM treatment should be identified and treated with doxycycline.

2.5 FISHERY DIVISION

2.5.1 Population Characteristics of *Chrysichthys nigrodigitatus* in the Weija Reservoir in Ghana

This study was undertaken to provide information on the population characteristics of *Chrysichthys nigrodigitatus* which would be helpful in the conservation and sustainable management of the species for food security and socio-economic development.

During the reporting year, monthly fish sampling was undertaken from the Dam Intake, Machigani and Galilea. The fishes were identified and standard length and weight measured for the computation of length frequency, length weight relationships and condition factor. The Catch Per Unit of Effort and sexes of individual fishes were also determined.

Out of a total number of 549 specimen of *C. nigrodigitatus* examined, 39.89 % were males, 55.19 % were females while 4.92 % were undetermined. The largest male specimen measured 33.5 cm and weighed 1000 g while the largest female measured 30.5 cm and weighed 800.0 g. *C. nigrodigitatus* females were of better condition and were better suited to the Weija environment than males as indicated by the mean condition factor of 1.9648 and 2.0253 for males and females, respectively.

2.5.2 Production Parameters and Economics of Small-Scale Tilapia Cage Culture with Micro Credit Support in Two Communities of Asuogyaman District - Ghana

This study started in 2009 to establish production pattern and profitability of small-scale tilapia cage farming when micro-credit and technical knowledge is provided to small-scale farmers.

Activities carried out during the reporting year included selection of community members at Tusker and South Senchi, conducting interviews, training qualified and selected members in cage fish farming and small-scale business management and planning in preparation for the granting of micro-credit loan managed by the Asuogyaman Rural Bank for the purpose of farming fish in cages.

Profitability projections showed that small-scale cage culture could make a profit (GH¢ 325.00) when feed cost could be reduced by 25 % and FCR to less than 1.5. Ninety percent

(90 %) fish survival/recovery further improved profit to GH¢ 650.00. Fish farmers could make appreciable yield and profits if they adhere to the use of good technical information and instructions provided to them in the choice of feed and its application to feeding fish. Furthermore, micro credit support properly packaged and extended could get poorly resourced farmers to undertake farming and improve their economic status.

2.5.3 Assessment of the Ecological and Public Health Status of a Water Storage Facility

The aim of the project was to assess the biological and environmental status of a Water Storage Facility (WSF) created by Newmont Ghana Ltd. with the view of enhancing its fish production. Activities carried out included fish sampling and identification, and measurement of fish length and weight. Five fish species caught during the study period were *Oreochromis niloticus*, *Clarias anguillaris*, *Clarias gariepinus*, *Parachanna obscura* and *Brycinus nurse*. The Nile tilapia, *O. niloticus*, was the predominant species in the WSF and constituted 93.2 % and 71.2 % by number and weight, respectively, of the total catch. This tilapia was followed by the catfish, *C. anguillaris*, and the snake head, *P. obscura*, which constituted 17.9 % and 9.7 %, respectively, of the total catch. The dominance of *O. niloticus* in the system could be explained by the stocking of the reservoir with *O. niloticus* after its formation. The diversity (H') and evenness (D_s) indices of 0.1323 and 0.1289, respectively, were low indicating poor diversity and distribution of species.

It was recommended that the water quality of the reservoir be improved by frequently diluting the water with fresh one while allowing some of the resident water out. Once the water quality is improved other species e.g. the Nile perch, *Lates niloticus* (carnivore), *Chrysichthys* spp and the bony tongue, *Heterotis niloticus*, could be introduced to ensure a more diversified and balanced fish community.

2.5.4 The Threat of Pesticide Residues to Fisheries of Bontanga Reservoir in Ghana

This study was undertaken to determine the impact of pesticide residues concentration on the condition factor of major fish species, namely, *Auchenoglanis occidentalis*, *Brycinus nurse*, *Clarias gariepinus*, *Hemichromis fasciatus*, *Marcusenius senegalensis*, *Oreochromis niloticus*, *Sarotherodon galilaeus* and *Tilapia zillii* of Bontanga reservoir during the dry and wet seasons.

Pesticide residues in fish were analyzed using Gas Chromatography and Solid Phase Extraction (SPE) via Turbo Vap II. Sixteen (16) organochlorine (OC) pesticide residues were identified in the reservoir.

During the dry season, heptachlor, p,p'DDE and p,p'DDD recorded concentrations of 0.094 µg/l, 0.061 µg/l and 0.019 µg/l, respectively. In the wet season, concentrations of γ -HCH and heptachlor were 0.075 µg/l and 0.069 µg/l, respectively. The condition factor (K) of the major fish species did not fluctuate significantly ($P < 0.05$) around the mean K of the individual species during the wet and dry seasons. The calculated acute risk ratio of the pesticide residues was less than 1.0 indicating that the concentrations were below toxic level to the fishes. However, this is still of concern considering the bio-accumulative nature of organo-chlorine compounds.

2.5.5 Evaluation of Selected Commercial Fish Feeds

This study was carried out to determine the most cost effective feed, compared the different feeds currently available on the market to producers and suggest interventions that will lead to increased fish productivity and better the livelihood prospects of fish farmers.

During the reporting year, experimental data on the study were obtained and analysed. Depreciation was computed using the straight-line method based on the estimated economic

life of the capital items. Costs and returns analysis was used to determine the return on investment (ROI) as a comparative indicator.

The capital outlay was valued at GH¢ 10,480.00. Food conversion ratios (FCR) of the feeds employed were estimated to range between 1.69 and 2.46. Crude protein varied from 30 – 36 % while the respective unit prices ranged between GH¢ 1.35 and GH¢1.80.

2.5.6 Catch Assessment and Reproductive Seasonality of Major Commercial Catfishes in Strata II and III of the Volta Lake

This study assessed the exploitation patterns of catfishes of the genera *Bagrus*, *Chrysichthys*, *Clarias* and *Synodontis* in the Volta Lake for sustainable management strategy development. Catch assessment was conducted by determining the composition of fish species by weight per major gear of commercial fishers, changes in relative abundance of fish species, length-frequency distribution, condition factor (K), catch per unit of effort (CPUE), seasonality of spawns, size at first maturity and relationship of catches and spawning activities with physico-chemical parameters of the lake. Fish species diversity and similarity between Dzemeni (Stratum II) and Kpando (Stratum III) study sites were conducted.

The total annual catfish production at Dzemeni was 806.19 tonnes while 443.53 tonnes was produced at Kpando-Torkor over the same study period. The clarotid catfishes of the genus *Chrysichthys* (i.e. *C. auratus*, *C. nigrodigitatus* and *C. walkeri*) dominated all catches in both Dzemeni and Kpando study areas. More than 50 % of claroteids were caught at sizes below 13.5 cm SL for *C. auratus* and below 17.5 cm SL for *C. nigrodigitatus* which suggested growth overfishing. At both study sites, only gillnet catches of *C. auratus* showed bi-modal length class distributions. The mochokids produced relatively higher numbers of eggs per female, ranging from 383 – 21,452 eggs. *S. schall* at Kpando (Stratum III) produced the least number of eggs among the mochokids as well as the highest number of eggs in the same Stratum III at Kpando. Diversity of fish species at Kpando-Torkor was significantly higher than at Dzemeni ($P < 0.05$). It was concluded that unapproved gillnet mesh sizes of less than 2 inches (51 mm) contributed to about 45 % of gillnet catfish landings of immature or first time spawning populations. Hence, Fishers should be identified by the gears they use, be registered in their respective fishing communities and be monitored regularly to facilitate effective management of the fishery resources.

3.0 OTHER ACTIVITIES

Other activities from the non-technical Divisions of the Institute included:

3.1 Public Education and Awareness Creation

Some of the major research and development activities of the Institute were showcased during exhibitions to increase awareness on the need for sustainable utilization, management and protection of water resources.

3.2 Consultancy and Advisory Services

A number of consultancy and advisory services were carried out by the Institute for various donor agencies, corporate bodies, governmental and non-governmental organizations, universities and polytechnics, public and private sector institutions as well as individuals. The significant ones included:

- Update on flood phenomenon in Ghana (Client: UNESCO)
- Managing water as a shared responsibility across geographical and social boundaries by promoting IWRM in the cluster countries: The case of Tano and Keta basins (Client: UNESCO)

- Assessment of innovative institutional arrangement and technical interventions in irrigation farming in northern Ghana (Client: IWMI)
- Impact of climate change on water resources of Ghana (Client: UNESCO)
- Water resources modelling with MIKE BASIN under the Sustainable Development of Research Capacity (SDRC) programme (Client: Glowa Volta Project)
- Geophysical survey, analyses and interpretation of data to select suitable drilling locations to supply underground water at a proposed Warehouse site at Apowa-Kadjebril near Takoradi (Client: COCOBOD)
- Geophysical survey at Nankese to drill additional borehole to supplement the existing supply source (Client: CSIR Mineral Water Co. Ltd.)
- Baseline environmental studies at Obuasi Anglogold Tailing Dump Sites by carrying out pumping test and data analyses of nine (9) monitoring boreholes (Client: Anglogold Ashanti Ghana Ltd.)
- Assessment of the ecological and public health status of a Water Storage Facility (Client: Newmont Ghana Gold Ltd.)
- Assessment of pond water quality and trace metal levels in fish (Client: Newmont Ghana Gold Ltd)
- Trace metal levels in fish and water quality assessment (Client: AngloGold Ashanti Ghana Ltd.)
- Assessment of ground and surface water quality (Client: Tarkwa Goldfield Company Ltd.)
- Physico-chemical and biological assessment of the quality of the Subri River and its tributaries (Client: MEST)
- Physico-chemical and bacteriological assessment of raw and treated water (Client: Vicco Ventures Limited)
- Water quality assessment of rainwater harvesting systems in Mfantiman, Abura Asebu Kwamangkese and Ajumako Enyan Essiam districts (Client: Plan Ghana Limited)
- Assessment of effluent quality (Client: PhytoRiker pharmaceuticals Limited)
- Assessment of effluent quality (Client: Pioneer Food Cannery Limited)
- Assessment of potable water quality (Client: Pioneer Food Cannery Limited)
- Physico-chemical and bacteriological tests on potable and swimming pool waters (Client: Golden Tulip Hotel)
- Final effluent quality monitoring (Client: Golden Hotel Limited)
- Assessment of the quality of swimming pool water (Client: Tesano Sports Club)

3.3 Administration

The Institute was managed by a 8-member Management Board chaired by Prof. C. Dorm-Adzobu, Dean of the Faculty of Arts and Social Sciences, Central University College, and a 20-member Internal Management Committee (IMC) chaired by the Director. Staff strength stood at 225 at the end of the reporting year. It was made up of 52 Senior Members, 76 Senior Staff and 97 Junior Staff. The list of Senior Members and Senior Staff is shown in Appendix I. There were 24 promotions, 8 retirements, 9 temporary appointments, 1 contract and 1 death during the year. Publications produced by staff is detailed in Appendix II.

3.4 Internally Generated Funds (IGF) in 2010

An amount of GH¢666,613.82 was generated from consultancy services out of which an expenditure of GH¢517,221.80 was made (Table 29). The IGF constituted 14.54 % of total receipts for the year.

4.0 Major Constraints

Major constraints faced by the Institute during the reporting year included lack of adequate equipment, chemicals and technical personnel at the laboratories. Financial constraints such as delays in release of funds for recurrent, research and developmental activities, and lack of adequate logistics for data collection also affected the programmes of the Institute negatively.

APPENDIX I: List of Senior Members and Senior Staff

DIRECTORATE

S. Dapaah-Siakwan
B.Sc. (Hons) Physics, (UST)
M.Sc. G/Water Hydrol. (VUB Belgium)
Ph.D. Tsukuba Univ. Japan
Principal Research Scientist
Acting Director

P. Gyau-Boakye
B.Sc. (Hons) Civil Eng. (UST)
M.Sc. Water & Waste Eng. (L'borough)
Ph.D. (Hydrology) Bochum
Principal Research Scientist

SURFACE WATER DIVISION

K. Kankam-Yeboah
BSc. Agric. & Dip. Ed. (UCC)
MSc. Tropical Agric. (CUL, LLN, Belgium)
MSc. Irrig. Eng. (KULeuven, Belgium)
PhD. Earth Science & Env. Eng. (Okaya., Japan)
Principal Research Scientist
Head of Division

E.O. Bekoe
BSc. Agric. Eng. (UST)
MSc. Soil & Water Eng. (Wageningen, Neth.)
PhD. Water & Environment (Cranfield, UK)
Research Scientist

S. Baah
Chief Technical Officer
Albert A. Agyapong
Principal Technical Officer

S.A. Akraasi
B.Sc. (Hons) Maths/Stats (Legon)
MSc. Soil Conservation & Land Reclamation
Eng. (Southampton)
Senior Research Scientist

Fredrick Yaw Logah
BSc. Agric. Eng. (KNUST)
MSc. Water Res. Eng. (KULeuven, Belgium)
Research Scientist

Collins K. Asante-Sasu
Principal Technical Officer

F.K. Amu-Mensah
BSc. Agric Eng. (UST)
MSc. Soil & Water Eng. (Wageningen)
PhD. Bioenv. Science (Tottori, Japan)
Senior Research Scientist

E. Obuobie
BSc. Agric Eng. (UST)
MSc. Soil & Water Eng. (Wageningen, Neth.)
PhD. Natural Science (Univ. Bonn, Germany)
Research Scientist

Gabriel Appiah
Technical Officer

B. A. Amisigo
BSc.(Hons) Agricultural Eng. (UST)
MSc. Water Res. Eng. (Guelph)
PhD. Hydrology/Water Res. Eng. (Delft)
Senior Research Scientist

GROUNDWATER DIVISION

B.K. Kortatsi
B.Sc. (Hons) Physics/Maths, (Legon)
M.Sc. Hydrogeol. (Univ. of B'ham)
Ph.D Geology (Univ. of Ghana)
Principal Research Scientist

Patrick A. Mainoo
B.Sc. Physics (KNUST)
MSc Physics (KNUST)
Research Scientist

James Owusu
Principal Technical Officer

A.A. Duah
B.Sc. (Hons) Geol. Eng (UST)
M.Sc. Groundwater Survey, GIS (ITC)
Research Scientist

Collins Okra
BSc (Physics) & Dip. Ed. (UCC)
MSc Geophysics (KNUST)
Research Scientist

Emmanuel A. Ayizemi
Technical Officer

W.A. Agyekum
B.Sc. Geol. Eng. (UST)
M.Eng. Groundwater Hydrology (Delft)
Research Scientist

Eric Yaw Darko
Technical Officer

ENVIRONMENTAL CHEMISTRY DIVISION

O. D. Ansa-Asare
B.Sc. (Hons) Chem.Dip.Ed. (UCC)
P.G. Dip. Water Quality Mgt. (Delft)
PhD. Env. Chem. (Aberdeen)
Principal Research Scientist
Head of Division

I. O. A. Hodgson
B.Sc. (Hons) Chem.Eng. (UST),
MSc. Chem. Eng. (UBC, Canada)
PhD Chem. Eng. (LU, UK)
Senior Research Scientist

A. Y. Karikari
B.Sc. (Hons) UST
MSc. Chem. (Univ. of Ryukyus, Japan)
Senior Research Scientist

Asmah Ruby (Mrs)
B.Sc. (Hons) Chem. (UST)
M.Sc. Ecol. Marine Mgt. (Belgium)
Ph.D Aquaculture (Uni. of Sterling, UK)
Research Scientist

Collins Tay
B.Sc. Chem. (KNUST)
M.Sc. Env. Res. Mgt. (KNUST)
Research Scientist

K. A. Asante
B.Sc. (Hons) Chem.(UST)
Cert. Protection & Utilization
of Oceans (Hamburg)
M.Sc. Env. Chemistry and Exotoxicology
Research Scientist

Joyce Amoako (Mrs.)
BSc Chem. (UST)
MSc Env. Sanitation (Belgium)
Research Scientist

Humphrey F. Darko
B.Sc. Chem. (UCC)
MSc Ecological Marine Mgt. (VUB)
Research Scientist

Samuel Obiri
BED Chemistry/Integrated Science
MPhil Inorganic/Analytical Chemistry
Research Scientist

Patience Atsakpo (Mrs)
Principal Technologist

Grace Dartey (Ms)
Senior Technologist

Michael Dorleku
Senior Technologist

Irene D. Adu-Poku
Principal Technical Officer

William E. Arko
Principal Technical Officer

Martha D. Agyemang
Principal Technical Officer

Zita Naangmenyele
Principal Technical Officer

Salifu Abdul-Latif
Senior Technical Officer

Sampson Abu
Senior Technical Officer

Emmanuel Adu-Ofori
Technical Officer

Michael Dankwa Afram
Technical Officer

ENVIRONMENTAL BIOLOGY AND HEALTH DIVISION

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B.Sc. (Hons) Botany & Dip. Ed. (UCC)
M.Phil. Micro. (Legon)
Ph.D Microbiology (Legon)
Principal Research Scientist
Head of Division

A. A. Opoku
BSc. (Hons) Biology (UST)
Dip. Env. Mgt. (TU Dresden)
Dip. Insect Taxonomy (Cardiff)
PhD Applied Entomology (Cardiff)
Senior Research Scientist

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B.Sc. (Hons) Zoology/Bot. (Legon).
M.Sc. Med. Ento. (Pond cherry)
Research Scientist

Gloria D. Addico (Ms.)
BSc. (Hons) Nat. Res. Mgt. (UST)
M.Phil. Biological Sciences (UST)
Ph.D Biological Sciences (Uni. of Hull)
Research Scientist

Ebenezer D. O. Ansah
BSc. Zoology (Legon)
M.Phil. Zoology (Legon)
Research Scientist

Felix Akpabey
BSc Zoology/Botany (UCC)
MSc Entomology (UG)
Research Scientist

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BSc. (Hons) Biol. Sciences
P.G.D.E. Biology/Integrated Science
MPhil Zoology (Applied Parasitology)
Research Scientist

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BSc. Biological Sci/Nursing (Legon)
MPhil Zoology (Legon)
Ph.D Medical Parasitology (McGill, Can)
Research Scientist

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BSc Botany (Legon)
MPhil Botany (Legon)
Research Scientist

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BSc. Zoology (Legon)
MPhil. Public Health (Legon)
Research Scientist

Wilhemina Tetteh
Senior Technologist
M. T. Sappor
Principal Technical Officer

Mohammed M. Bello
Principal Technical Officer

Lady A. Frimpong
Principal Technical Officer

Sena Niampomah
Principal Technical Officer

Ruth Amole (Mrs)
Technical Officer

FISHERY DIVISION

J. K. Ofori
BSc. (Hons) Biology (UST)
MTech. Aquaculture (Port Harcourt)
PhD Biol. Sciences (UST)
Senior Research Scientist
Head of Division

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BSc. (Hons) Zool./Bot. (Legon)
MSc. Marine Ecol. (Brussels)
Dip. Fish Mgt.
PhD Fish Biol./Aquac. (UCC)
Senior Research Scientist

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BSc. (Hons) Zool./Bot (Legon)
MSc. Aquaculture (Auburn)
PhD Aquaculture (Auburn)
Research Scientist

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BSc. (Hons) Zool/Bot. (Legon)
MSc. Aquaculture (Stirling)
Ph.D Zoology (UCC)
Research Scientist

K. Agbogah
BSc. (Hons) Zool./psych. (Legon)
MSc. Env. Sci. & Tech. (Delft)
Cert. Rem. Sen. & Env. Mgt.
Research Scientist

K. Kwarfo-Apegyah
MSc. Fisheries Mgt. (Ibadan)
Research Scientist

F. Amevenku
BSc. (Hons) Nat. Res. Mgt. (UST)
MPhil. Agric. Economics (Legon)
Research Scientist

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BSc. (Hons) Nat. Res. Mgt. (UST)
MPhil Biological Sciences (UST)
Research Scientist

Seth K. Agyakwah
BSc. (Hons) Biological Sc. (UST)
MPhil Fisheries Science (UG)
Research Scientist

Francis Assogba Anani
BSc Zoology
MPhil Fishery Science
Research Scientist

K. Atsakpo
Senior Technologist

Lilly K. Osei
Principal Technical Officer

E. K. Amerdome
Senior Technical Officer

Martin A. Adakpeya
Technical Officer

Eric J. Darko
Technical Officer

COMMERCIALIZATION AND INFORMATION DIVISION

Marian A. Jiagge (Mrs.)
BLS. (A.B.U Zaria)
MLS (Legon)
Librarian
Head of Division

Marian Amu-Mensah (Mrs.)
BSc. Art (UST)
Asst. Scientific Secretary

Benson Kwabena Owusu
B.Ed. Science (UCC)
M.Phil. Env. Science (UG)
Scientific Secretary

Thomas K. F. Adom
B.A. Dip. Educ. (UCC)
CIM (UK)-Advanced Cert.
Asst. Marketing Officer

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Dip. Library & Info.Sci. (Legon)
BA – Information Studies with study of Religions (UG)
Assistant Librarian

Sylvia Amponsah
Principal Technical Officer

R. Sapah
Chief Draughtsman

H. Komladzei
Principal Draughtsman

S. Siaw-Kroduah
Principal Draughtsman

Francis Annor Boakye
Senior Technical Officer (ICT)

Richard Kwapong Kwayisi
Assistant Printer

FINANCE DIVISION

Paul Fabalona
BSc. Accounting (IPS)
Chartered Accountant (ICA-GH)
Accountant

N. Y. Biritwum
Chief Stores Supt.

Godwin N. Dohertso
Chief Accounting Asst.

Kwame Osei-Mensah
Chief Accounting Asst

Charles K. Dzokoto
Principal Accounting Asst.

J. H. Baffoe
Principal Accounting Asst.

Joshua Osuteye
Principal Stores Supt.

A. A. Yoatey
Senior Accounting Asst.

A. Dei
Senior Accounting Asst.

E. Nii. Dodoo Koranteng
Senior Accounting Asst.

John A. Akuoko-Baafi
Accounting Assistant

Esther Mate-Ahmed (Mrs)
Accounting Assistant

ADMINISTRATION DIVISION

Margaret A. Sedziafa
BA (Hons) English Lang. & Hist.
(UCC)
Graduate Dip. in Library Std. (Legon)
MBA Human Resource Mgt. (Legon)
Senior Admin. Officer

S. A. Tagoe
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J. C. K. Eworde
Chief Admin. Asst.

Claudia Bentum (Mrs)
Principal Admin. Asst.

Godfried Acquaaah-Arhin
Senior Admin. Asst.

Joyce Osibo
Senior Admin. Asst

Agnes Darko
Admin. Asst. (Sect)

Rebecca Yankson
Admin. Asst (Sect)

Vivan Osae
Admin. Asst (Sect)

Transport Section
S. Q. Teivi
Principal Works Supt. (Auto)

Johnson K. Adonkor
Snr. Works Supt. (Auto)

Robert Azongo
Snr. Works Supt. (Machine)

Kenneth K. Opare
Snr. Works Supt. (Auto)

Samuel O. Agyei
Asst. Transport Officer

John K. Kpamah
Asst. Transport Officer

Alex A. Yeboah
Asst. Transport Officer

Samuel Annang
Asst. Transport Officer

Edem K. Ayegbe
Asst. Transport Officer

Matthew Kwara
Asst. Transport Officer

Samuel K. Nikoi
Asst. Transport Officer

Benjamin K. Kodjo
Works Superintendent

Samuel K. Osafo
Works Superintendent

Security Section
Samuel O. Ankrah
Security Officer

Anthony Arko
Security Officer

Estate
Simon K. Anane
Estate Assistant

APPENDIX II: List of Staff Publications

Administrative Reports

Agyekum, W. A. and Dapaah-Siakwan, S. (2010) Borehole sites selection at CSIR Mineral Water Co. Ltd. Factory Premises, Nankese, CSIR WRI, Accra.

Amoako, J. (2010) Sustainability of final effluent quality for irrigational purposes, CSIR WRI, Accra.

Asmah, R. (2010) Preliminary Environmental Report for the Aquaculture Research and Development Centre (WRI/ARDEC), CSIR WRI, Accra.

Kortatsi, B. K., Amevenku F. K. Y., Kankam-Yeboah, K., Hodgson I. O. A., Tay, C. and Mainoo P. A. (2010) Report on Water Resources Inventory and source identification for water supply to rural communities in Yilo Krobo District (WSSP Phase II), CSIR WRI, Accra.

Kortatsi, B. K., Amevenku, F. K. Y., Kankam-Yeboah, K., Hodgson I. O. A., Tay, C. and Mainoo, P. A. (2010) Report on Water Resources Inventory and source identification for water supply to rural communities in Lower Manya Krobo District (WSSP Phase II), CSIR WRI, Accra.

Kortatsi, B. K., Amevenku, F. K. Y., Kankam-Yeboah, K., Hodgson, I. O. A., Tay, C. and Mainoo, P. A. (2010) Report on Water Resources Inventory and source identification for water supply to rural communities in Upper Manya Krobo District (WSSP Phase II), CSIR WRI, Accra.

Conference Papers

Asmah, R. (2010) Aquaculture Site Selection and Carrying Capacity Estimates for Inland and Coastal Water bodies – A case study of West Africa. Paper presented at the Aquaculture site selection and carrying capacity estimates for inland and coastal waterbodies workshop, 6 – 8 December 2010, Stirling

Obuobie, E. (2010) Assessment of the Pra River Basin to water stress conditions under changing climate. Paper presented at the 9th CTWF International Workshop on Climate and Environmental Change: Challenges for Developing Countries, 17 – 19 November 2010, Beijing (http://ctwf.icces.ac.cn/ctwf2010/abstract_show.asp?id=446)

Consultancy Reports

Agyekum, W. A., Mainoo, P. A., Dapaah-Siakwan, S. and Okrah, C. (2010) Borehole drilling and pumping test of nine (9) monitoring boreholes at Anglogold tailings dump sites, Obuasi, CSIR WRI, Accra.

Amoako, J. (2010) Assessment of final effluent quality. Report prepared for Phyto-Riker (Gihoc) Pharmaceuticals, CSIR WRI, Accra.

Amoako, J. (2010) Assessment of Effluent quality. Report prepared for Pioneer Food Cannery Limited, CSIR WRI, Accra.

Amoako, J. (2010) Final Effluent Quality. Report prepared for Ghacem Limited, CSIR WRI, Accra.

Amoako, J. (2010) Potable Water Quality Studies. Report prepared for Pioneer Food Cannery Limited Tema, CSIR WRI, Accra.

Amoako, J., Karikari, A. Y., Hodgson, I. O. A., Ampofo, J. A., Amevenku, F. and Banu, R. (2010) Water Quality Assessment of Rainwater Harvesting systems in Mfanstiman, Abura Asebu Kwamangkese and Ajumako Enyan Essiam Districts. Report prepared for Plan Ghana, CSIR WRI, Accra.

Ansa-Asare, O. D. (2010) Baseline Environmental Studies: Water Quality assessment of surface and groundwater at Anglogold Ashanti concessions in Obuasi, CSIR WRI, Accra.

Ansa-Asare, O. D. (2010) WRIS Annual Water Quality Assessment Report, CSIR WRI, Accra.

Ansa-Asare, O. D. and Asmah, R. (2010) Ground and Surface Water Quality Assessment Programme. Report prepared for Goldfields Ghana limited, CSIR WRI, Accra.

Ansa-Asare, O. D., Entsua-Mensah, R. E. M., De-Graft Johnson, K. A. A., Amevenku, F. K. Y., Ampofo, J. A., Amakye, J. S., Akraasi, S. A. and Asante, K. A. (2010) Survey of Polluted Coastal Water Bodies in Ghana (GCLME Project), CSIR WRI, Accra.

Asmah, R., Karikari, A. Y. and Ansa-Asare, O. D. (2010) Trace Metal Levels in Fish and Water Quality Assessment. Report prepared for AngloGold Ashanti-Obuasi, CSIR WRI, Accra.

Asmah, R. and Ansa-Asare, O. D. (2010) Water quality assessment report for parts of the Volta Lake, CSIR WRI, Accra.

Asmah, R., Dankwa, R. H., Opoku, A. A., Armoo, S., Mensah, G. T., Akpabey, F., Addico, G. N. D. and Amevenku, F. (2010) Assessment of the Ecological and Public Health Status of a Water Storage Facility. Report prepared for Newmont Ghana Gold Ltd., CSIR WRI, Accra.

Dapaah-Siakwan, S., Ansa-Asare, O. D., Mainoo, P. A., Adico, G. N. D., Okrah, C. and Darko, H. F. (2010) monitoring groundwater resource occurrences and their quality in the Tano and Pra River Basins with surface water quality monitoring in the South-western, Coastal and Volta River Basins, CSIR WRI, Accra.

Dapaah-Siakwan, S., Kankam-Yeboah, K., Okrah, C., Agyekum, W. A., Ofori, D. and Amoah Adarkwah, E. S. (2010) Managing water as a shared responsibility across geographical and social boundaries by promoting IWRM in the cluster countries: The case of Tano and Keta basins, UNESCO-ISARM Project for UNESCO-Cluster Office, CSIR WRI, Accra.

Kankam-Yeboah, K., Obuobie, E., Amisigo, B. and Opoku-Ankomah, Y. (2010) Climate change effects on hydrology and water resources and adaptation strategies in Ghana. Report prepared for UNESCO, CSIR WRI, Accra.

Karikari, A. Y. (2010) Final Effluent Quality Monitoring. Report prepared for Golden Tulip Hotel, CSIR WRI, Accra.

Karikari, A. Y. and Akpabey F. (2010) Assessment of the Quality of Tesano Sports Club Swimming Pool Water. Report prepared for Tesano Sports Club, CSIR WRI, Accra.

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