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International Atomic Energy Agency

BOARD OF GOVERNORS
GENERAL CONFERENCE

Sub-item 17(c) of the Conference's provisional agenda
(GC(45)/1)

SERVICING IMMEDIATE HUMAN NEEDS

1. Resolution GC(44)/RES/24 requests the Agency "within available resources, to facilitate, in co-operation with Member States and relevant international organizations, all efforts for:

(a) initiating research and development (R&D) activities that would lead to possible application of the sterile insect technique (SIT) for the control or eradication of mosquitoes;

(b) building up indigenous capabilities in radiation therapy to cure or alleviate the debilitating disease of solid cancers in developing Member States and improving the implementation of safety standards; and

(c) strengthening R&D activities in order to ascertain the possibility of applying nuclear techniques for locating land mines".

It further requested the Director General to "report on the feasibility and resource implications of this resolution to the Board of Governors and to the General Conference at its forty-fifth session under an appropriate agenda item".

I: STERILE INSECT TECHNIQUE FOR THE CONTROL OR ERADICATION OF MOSQUITOES

Background

2. Malaria is the most important insect transmitted disease. The causative agents are parasites of the genus *Plasmodium* that are transmitted by female mosquitoes of the genus *Anopheles*. It causes approximately two million deaths a year and there are about 300–500 million cases of clinical malaria annually. Over 90% of the world's malaria cases occur in Africa, and in many countries it consumes a major portion of the national health budget. The disease constitutes a major obstacle to poverty reduction in Africa; according to some estimates, it has slowed economic growth in African countries by 1.3% per year. As a result of the compounded effect over 35 years, the GDP for African countries is now up to 32%

lower than it would have been in the absence of malaria. The burden that malaria places on societies and economies was recognized when 48 African Heads of State and Government met in Nigeria in April 2000 and adopted the Abuja Declaration on Roll Back Malaria (RBM) in Africa. This declaration stresses the regional commitment to reduce malaria mortality in Africa by half by 2010 and calls upon development partners to allocate substantial new resources of at least $1 billion per year to combat the disease. The Abuja Summit also recorded the governments' commitment to increase support for research to facilitate the development of new investigative and control tools and to improve existing ones. The adopted Plan of Action emphasizes the importance of human resources development and calls for intensified research on issues of direct significance to national control programmes.

3. Early treatment for malaria requires affordable and effective drugs but there are growing problems of drug resistance, which will increasingly limit the efficacy of the current first-line drugs and necessitate a switch to more expensive alternatives. Insecticide treated bed nets (ITNs) have proved a valuable control tool but resistance to pyrethroid insecticides, already reported from several countries in Africa, could limit the efficacy of ITNs if it were to become more widespread. Whilst a malaria vaccine has often been regarded as the 'magic bullet' against malaria, in recent trials of candidate vaccines, none have proved sufficiently protective against malaria to warrant use in malaria control and it is increasingly unlikely that an effective vaccine can be deployed before 2011 at the earliest. Even when one is available, the belief is that a vaccine should be deployed alongside other control methodologies. These factors have led to renewed interest in the potential of the SIT for the suppression of mosquito vectors in suitable areas.

4. The remarkable success of area-wide SIT programmes against screwworm, tsetse and fruit flies provides a sound basis for contemplating the prospects for SIT intervention to suppress populations of malaria vectors. It is envisaged that SIT would be used under specific conditions as an adjunct to other, more orthodox technologies. This would conform with the current RBM strategy of not relying on any single approach. SIT relies on mass rearing and release of sterilized insects. The released males mate with wild female flies, preventing production of offspring and thus leading to population control and, following repeated releases, eventual eradication.

Action Taken by the Secretariat

Current and Planned Activities

5. The Agency convened two consultants meetings — in 1993 and 1996 — to advise on the possible use of SIT for the control of malaria mosquitoes. Both consultant meetings recognized the potential of SIT for area-wide control of mosquitoes, but noted that the technology for field application did not exist and substantial R&D was needed to develop the methods required. The R&D would be implemented through activities at the Seibersdorf Laboratory and through a co-ordinated research project (CRP). The consultants envisaged a budget of about $6.5 million over a period of 5 years for one *Anopheles* species to cover staff and operational costs and facilities for conducting the studies.

6. The Agency initiated a regional technical project for the biennium 2001–2002 with the following objectives: (a) to support, refine and provide training in mosquito mass rearing, ecology, epidemiology, radiation sterilization and genetic sexing in relevant laboratories in

selected countries in Africa and elsewhere; (b) to conduct field surveys and baseline data collections at possible field sites including mark-release-recapture studies, remote sensing and GIS (Geographical Information System), ELISA (enzyme-linked immunosorbent assay) to determine parasite rates in mosquitoes and vector dynamics; (c) to contribute to improved capacity building in malaria research in the affected countries and establish a network of laboratories where expertise in mosquito SIT is consolidated; and (d) to collaborate with other international and regional partners to co-ordinate the elaboration of an SIT feasibility study for mosquito SIT.

7. The Agency has identified as core activities unfunded in the regular budget (CAURBs) R&D activities for 2002–2003 estimated to cost $690 000 in 2002 and $503 000 in 2003. Until now, $100 000 per annum is available from the Regular Budget and, in addition, the Agency has obtained, for activities to be conducted at the Seibersdorf Laboratory, extrabudgetary financial resources from the US Government amounting to $250 000 per annum to cover the cost of a cost-free expert and laboratory operations for an initial period of three years.

8. In June 2001, the Agency convened a meeting involving national experts from 8 African countries, international experts and a representative from WHO, under the auspices of regional technical co-operation project RAF5052, to: (a) review the status of the control of malaria transmitting mosquitoes in Member States, including government policies; (b) review the state of art for possible use of SIT for the control of malaria transmitting mosquitoes; (c) formulate long-term and short-term strategies and action plans for R&D aimed at possible use of SIT for the control of malaria-transmitting mosquitoes; and (d) identify international and regional partners and discuss modalities for co-operation. Among the findings and conclusions of the meeting are:

- Compared to the initial trials of using SIT for malaria control in the early 1970s, the technology has developed enormously in terms of delivery mechanisms of sterile males, the molecular basis to develop sexing strains and in sterilizing the males themselves. In addition, quality assurance mechanisms have become more refined and links with the Anopheles genome project have also been established improving development of transgenic mosquitoes. Technology such as GIS/GPS (Geographical Positioning System) has facilitated the field evaluation of SIT.

- Any mosquito SIT feasibility study will require a substantial R&D component which will address the following issues:

  (a) Developing methods of mass rearing: research will be conducted on critical aspects of large scale Anopheles rearing including adult holding, egg handling, larval rearing and pupal collection. This will include improving membrane feeding of adult females and improvements to blood diet or substitutes;

  (b) Improving sterilization, handling and release methodology: radiation procedures will be evaluated to enable pupae to be efficiently sterilized and thus reduce the need for excessive handling of the more sensitive adults. Techniques for aerial release will also have to be investigated;

(c) Devising genetic and molecular methods for the production of males: Any SIT programme for mosquitoes will require the release of males only. Genetic sexing methods will need to be developed;

(d) Improving field evaluation of release mosquitoes: this will entail developing methods for assessing male competitiveness, migration and monitoring of release mosquitoes.

9. The June 2001 meeting defined a five-year project aimed at developing and evaluating SIT technology for *An arabiensis* in the Africa Regio*n* as described in paragraph 6 above. The scope of this initial project is limited to: (a) laboratory R&D of SIT technology for *An. Arabiensis;* (b) the collection of baseline data from field site(s); (c) training and capacity building in a network of centres in Africa. The project will also involve establishing an improved network of centres in Africa, together with strengthened collaboration with centres of excellence elsewhere. A project document has been prepared that would guide future work and would be used by the Agency and Member States to solicit donor support. The funding requirements for the 5-year project amount to $4.64 million. Some of the activities will be implemented using existing and pledged funds (see paragraphs 5 and 7 above); more activities will be initiated as funds become available.

Co-operation with other Organizations

10. The WHO, as the UN organization responsible for the RBM initiative, will be an important co-operating partner in the ongoing and planned activities. Its specific contribution will be to provide, where needed, expert advice and operational and technical support to recipient countries in Africa. In particular, the programme will exchange relevant scientific and technical information with the molecular entomology component of the WHO's Tropical Diseases Research (TDR) programme. WHO was involved in the planning meeting referred to in paragraphs 8 and 9 above.

II: RADIOTHERAPY FOR CURING OR ALLEVIATING SOLID CANCERS IN DEVELOPING COUNTRIES

Background

11. Cancer is a major cause of death in developed countries, and the number of cases in developing countries is growing rapidly as life expectancy increases. While the estimated 10 million cases of cancer world wide in 2000 are more evenly divided between industrialised and developing countries, out of the projected 15 million cases in 2015 about 10 million will be in developing countries.

12. It is fully recognized that radiotherapy is a valuable tool in both the cure and palliation of cancer. Currently, about 50% of cancer patients require radiotherapy. Improving precision in radiotherapy administration enhances safe and effective radiation treatment. To achieve this goal, comprehensive quality assurance (QA) programmes should be established to cover all steps, from clinical evaluation to dose delivery, to give optimal treatment to the patients with minimal exposure to personnel and the public, thus, improving safety standards.

13. Member States, through their health sectors, have demonstrated a commitment to the establishment and expansion of radiotherapy services, commensurate with their ability to

sustain them. The major constraints identified have been inadequate number of trained practitioners and poor quality assurance of the existing equipment. Most countries, with the exception of the smallest and poorest, have provided equipment for the radiotherapy of their cancer patients proportional to their GNI (Gross National Income)/capita. In assisting to build up indigenous capabilities in radiation therapy, the Agency's activities have focused on training practitioners and improving the utilisation and quality of therapy equipment, thereby increasing treatment effectiveness. In a few countries the Agency has assisted Member States in the initiation of services.

Action Taken by the Secretariat

Current and Planned Activities

14. The Agency, in conjunction with the European Society for Therapeutic Radiology and Oncology (ESTRO), North American organisations, and Pan American Health Organisation (PAHO) has compiled a world-wide Directory of Radiotherapy Centres (DIRAC) which is constantly updated. DIRAC includes data on personnel, teletherapy machines, devices used in brachytherapy and clinical and physical quality assurance equipment. The data collected from more than 160 countries (i.e. beyond IAEA membership) include about 6300 radiotherapy machines and 2500 brachytherapy units, about one third of which in developing countries.

15. The assessment of personnel skills and quality of equipment constitutes a more difficult task. Dose delivered in response to a prescription is one parameter that may be determined. However, it is estimated that not more than 50% of radiotherapy facilities world wide have participated in some level of dose quality audit. Genuine concern exists that some, or even many, facilities not involved in external quality programmes may deliver inferior radiotherapy treatments due to inadequate dosimetry practices. The IAEA/WHO TLD (Thermoluminescent Dosimetry) dose audit constantly accrues new participants desiring to verify their local practices. The programme checks approximately 400 clinical beams per year and has checked approximately 4000 radiotherapy beams in more than 1100 hospitals. Follow-up actions on deviations are taken aimed at helping hospitals to resolve the discrepancies, thus preventing further errors of treatment. The codes of practice on absorbed dose determination in radiotherapy beams developed by the IAEA take into account the recent developments in the field, and a new Code of Practice published in 2001 has been endorsed by WHO, PAHO and ESTRO.

16. The quality of clinical practice is quantifiable only with long term patient follow-up for survival and morbidity. This task is poorly accomplished in countries where the cost of returning to the treatment centre is a major financial burden. The Agency assists developing Member States by validating the initial treatment administered by testing clinical protocols in these countries and researching protocols which spare scarce personnel and equipment resources. This information is disseminated and reinforced through training courses such as those conducted through the regional technical co-operation project RAF/6/024 "Management of most common cancers of Africa". This project will, *inter alia*, address the palliative radiotherapy management of AIDS-related cancers peculiar to this region where some countries have HIV infection rate of over 35%.

17. Cervical cancer, endemic in many developing countries, is addressed in regional TC projects RAF/6/014 and RAS/6/035. The most extensive training was provided under regional

TC projects RER/6/008, RER/6/009 and RER/6/012 under which an average of 100 East European specialists annually participate in the training provided by ESTRO to their West European colleagues. From 2001, the Agency plans to hold one ESTRO training course in Russian as well, increasing the number of trainees to about 140 per year. So far, an average of 15 training courses in Radiation Oncology and Medical Physics have been run annually; the number is expected to increase in 2002 with the commencement of regional TC project RAF/6/027 “Strengthening Regional Capability in Medical Physics”.

18. Lack of professional education has been identified as a severe limiting factor in all developing regions. This is attributable to the paucity of adequate training centres because of the absence of critical mass of trainers. In medical physics a university course has been established under regional TC project RLA/6/041 “Masters in Medical Physics”. The majority of Latin American countries lack specialists in medical physics and there is a need to increase the knowledge of the medical physicists already working in hospitals. Presently, only 300 medical physicists are available, of whom 60% are working in Brazil, while available statistics indicate that the region needs 1,300 medical physicists. Moreover, not all of the 300 medical physicists in the region have an academic degree to qualify them to work in hospitals. A proposal for a similar course has been made for the East Asia and the Pacific region.

19. Clinical radiation oncology requires 4 years of post medical training for registration - at prohibitive cost to Member States lacking training centres. The availability of distance learning materials in the basic sciences of radiation oncology will permit more training to be effectively undertaken in the Member State permitting a reduced sojourn at established training centres outside of the country. Currently, 63 modules are under development by Australia under regional technical co-operation project RAS/6/033 and will be completed by the end of 2002. Plans are already underway to utilize this material in Africa in English and French, and in Latin America in Spanish. China plans to translate the material into Chinese. A Russian translation will also be prepared. The material may also be utilized in training allied professionals.

Resource Implications

20. In 2000, a total of 71 technical co-operation projects (9 regional and 62 national) on radiation therapy of cancer and medical physics were implemented with a budget of $7.6 million. For Newly Independent States (NIS) of the former Soviet Union the assistance from the Agency included a major component of equipment. In the last five years, Ethiopia, Ghana, Mongolia, Namibia and Uganda commenced modern radiotherapy treatment. Yemen is the only Member State currently in the process of acquiring these services with Agency assistance. The demand for Agency assistance by Member States is expected to continue as the few remaining Member States without radiotherapy equipment identify the need for such services and new countries join the Agency.

21. It is evident, however, that the Agency does not have the resources to comprehensively supply each Member State with therapy equipment. Nor is it likely that Member States have the resources to maintain and staff such facilities. The Agency strategy is to focus on technology transfer to a country - not complete coverage with cancer services. To that end technical co-operation projects on radiation therapy of cancer and medical physics are increasingly concentrated on the establishment of “Centres of Competence” in each Member State. Independent audit teams check the Agency intervention to determine if all the

components of the technology of Radiation Oncology are finally present and being operated according to good clinical, medical physics and radiation safety standards. These audits commenced in 2000 in Africa and in 2001 in Eastern Europe, and will continue until each interested developing Member State has had the opportunity to receive feedback from an authoritative and impartial source.

22. Insufficient resources to cover the investment costs of training and equipment for radiation therapy pose a great problem in developing countries. Cost and staffing requirements are essential elements in the choice. Costs entail initial set-up expenses and subsequent operational costs, including maintenance. The Agency has recently produced guidelines for the components of radiotherapy technology - TECDOC 1040 “Design and implementation of a radiotherapy programme: Clinical, medical physics, radiation protection and safety aspects”. These guidelines have been prepared to ensure that, with good planning, valuable items of equipment are not left unused or misused because of the absence of a small but essential component. Publications on the use, staffing and funding of specialised items such as micro-source High Dose Rate brachytherapy have also been prepared. A co-ordinated research project (CRP) will commence in 2001 to assess the historical comparative capital and operation cost of cobalt and linear accelerator teletherapy equipment in industrialised and developing countries.

Co-operation with other Organizations

23. A number of training courses were organized in co-operation with regional or international professional organizations, primarily ESTRO and the International Society of Radiation Oncology (ISRO).

24. The WHO’s International Agency for Research on Cancer (IARC), Lyon, France has co-operated in integrating cancer registries into Agency TC activities where cancer treatment services are initiated. There has been increased interaction between WHO Geneva and the Agency in evaluating research, preparing position documents and, from 2002, joint training courses in Africa are planned. WHO and ESTRO endorsed the new IAEA code of practice for radiotherapy dosimetry. A new international code of practice for X-ray dosimetry in diagnostic radiology, which is under development, will be co-sponsored by WHO.

III: NUCLEAR TECHNIQUES FOR LOCATING LAND MINES

Background

25. There are more than 60 million landmines buried in at least 70 countries all over the world. Landmines are lethal remnants of armed conflicts during the past century. Abandoned landmines maim and kill over 26 000 persons every year. Most of the victims of landmines are women, children and farmers in developing countries. For example, in Angola one out of 350 persons is a landmine amputee; Cambodia has more than 25 000 amputees as a result of accidents with landmines or unexploded ordnance. Landmines affect the daily lives of more than 22 million people. Furthermore, abandoned landmines are creating vast socioeconomic problems by inhibiting the return of refugees to their homes and the use of land for agricultural needs.

26. Landmines can be encased in metal, plastic, wood or nothing at all. Their fusing mechanisms vary from pressure triggers and trip wires to light and magnetically triggered fuses. They are often buried in fields, which get cluttered with metal debris, and covered by vegetation. The United Nations recommends a clearance rate of 99.6% down to 20 cm below the surface. At present, most of the humanitarian demining is done using metal detectors, prodder sticks and sniffer dogs, making the process of removing the landmines painstakingly slow. Ground penetrating radar and infrared imaging are also being increasingly used. Most of the instruments used today for detecting landmines are not really mine detectors as they are sensitive to secondary features of the landmine such as metal parts or the shape. They often locate objects that may not be landmines (anomalies) – they do not provide information on the presence of an explosive agent. Thus, the major problem in demining is to determine if an anomaly found in the ground is a landmine or not. This makes the procedure for locating and destroying the millions of landmines very slow, dangerous and expensive. The cost of removing an anomaly, with all the care and attention given to a landmine, is estimated at up to $1000 per mine cleared.

27. Nuclear methods utilizing neutron radiation are some of the very few techniques available that are able to determine whether a concealed object contains an explosive agent or not. The advantages of neutrons are that they penetrate thick layers of material and provide elemental information through characteristic photon emission induced by neutron scattering and activation. As explosives used in landmines contains a large fraction of nitrogen or oxygen, absorption of neutrons results in the emission of high- energy characteristic gamma rays that can be detected and used as an explosives indicator. So by first identifying anomalies by conventional methods and then using nuclear methods for detection of explosives, demining can proceed in a safe and efficient manner.

28. One of the instruments under development uses a pulsed fast and thermal neutron analysis (PFTNA) technique in which a small sealed tube neutron generator injects neutrons into the ground in 10-microsecond pulses. As a result of these neutron pulses, the carbon, oxygen and nitrogen in the ground emit gamma rays at various times with various energies, and the hydrogen in the ground causes backscatter of the neutrons. By measurement of these gamma rays and backscattered neutrons, a nuclear instrument can determine the ratios of these elements in the buried object, from which the computer can determine whether it contains explosives.

29. Extrabudgetary contributions in support of the Agency's activities related to demining have already been received from Turkey ($2000) and Korea ($25 000).

Action Taken by the Secretariat

Current and Planned Activities

30. Twelve laboratories from both developed and developing Member States are participating in a CRP on "Application of Nuclear Techniques to Anti-personnel Landmines Identification". The CRP has shown that methods based on neutron interrogation can identify the explosive content of a buried mine. Within the CRP several devices based on various techniques are being developed. A flexible approach is used to assess these and other nuclear methods applicable for humanitarian demining regularly as they mature. The key issues are

- sensitivity: (can the instrument detect less than 100 g of explosive?)
- depth: (can the instrument detect explosives at depths > 10 cm?)
- time: (can a reliable measurement be obtained in a few minutes to identify the presence of explosive in a buried object?)

In practice it will be desirable to have at least one instrument (such as a metal detector or radar) to locate buried objects and another instrument (such as a nuclear instrument) to identify the contents of the buried object.

31. A regional technical co-operation project in Europe *"Field Testing and Use of Pulsed Neutron Generator for Humanitarian Demining"*, which started in 2001, focuses on one technique only and one geographical region with a view of being more manageable and realistic. The first project planning and co-ordination meeting, held in February 2001 considered various alternatives and concluded that a PFTNA type instrument called PELAN should be procured under the project and deployed in an extensive field testing programme. PELAN has been developed and successfully used in the USA for detection of unexploded ordnance (UXO), chemical warfare agents and improvised explosive devices, but it needs adaptation for use in landmine identification in terms of sensitivity, time of detection and suitability for field condition.

32. The PELAN instrument has been ordered, an export license obtained, and its delivery to the Agency is expected by November 2001. Six people were trained in its use at Western Kentucky University, USA, in May 2001. The PELAN instrument will be transferred to a Member State in Europe with a suitable research laboratory, and laboratory tests will be performed using various types of soils, dummy mines and explosives. Subsequently, field trials will quantify the instrument's speed, sensitivity, accuracy and reliability, in simulated and real mine fields. Recently the US Government offered a $213 000 contribution in support of this technical co-operation project. If the results of the adaptation are positive, then PELAN could form the basis for the development of a humanitarian demining multi-sensor system. These results would guide the assessment of the resources required for such a development.

33. In the June 2001 issue of the IAEA Bulletin, the Secretariat published an article entitled "Humanitarian Demining: Nuclear Techniques May Help the Search for Landmines", which describes its humanitarian demining activities.

Co-operation with other Organizations

34. The Agency co-ordinates its activities with those of: the United Nations Mine Action Service (UNMAS); the European Commission Action for Research and Information Support (ARIS) in civilian demining; the Geneva International Centre for Humanitarian Demining (GIC); Joint Research Centre (JRC) Ispra, Italy; Instituto Nazionale di Fisica Nucleare (INFN), Padova, Italy; the Standing Committee of Experts on Technologies for Mine Action (SCETMA); and the national programmes of several countries. In the year 2000, the Agency participated in the "International Meeting on the Advances in NQR Detection of Land Mines and Explosives" (Slovenia) in the Standing Committee of Experts on Demining Technologies (Geneva); and in the "International Conference on Explosive and Drug Detection Techniques" (Crete).

RECOMMENDED ACTION BY THE BOARD

35. It is recommended that the Board take note of this report and authorize the Director General to submit it to the General Conference at its forty-fifth regular session.