REPORT OF THE

FAO/IAEA CONSULTANTS MEETING

ON

RADIATION PROCESSING OF SEWAGE SLUDGE AND ITS USE TO INCREASE CROP YIELDS, AND TO PRESERVE THE ENVIRONMENT

5 - 9 December 1994

Soil Fertility, Irrigation and Crop Production Section
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
1. INTRODUCTION

Rapid urbanization brings forth many problems and the problem of utilization and disposal of sewage sludge is a serious one in many cities. One of the applications of sewage sludge is in the area of agriculture and horticulture. Sewage sludge has essential nutrients for plant growth like N, P, K, micronutrients like Zn, Fe, Cu, Mn, other trace elements and considerable organic matter. However, they also contain pathogenic organisms, heavy metals and other toxic materials coming from industries. Because of health problems, applications of sewage sludge to agricultural lands is restricted. Also land applications have to be carefully made so that heavy metals do not accumulate to toxic levels in plants and enter into food chain or it may accumulate in soil and enter groundwater. There are number of reviews on various aspects of sewage sludge regarding its utility as fertilizer in crop production, phytoxicity, plant tissue concentration of nutrients and pathogenic organisms. The risk posed by pathogens and helminths for utilization of sludge for agriculture is mitigated by the use of irradiation as a pre-treatment. There is sufficient technical data available for gamma treatment of sludges, permitting its application on the demonstration or commercial scale, but a few gaps in knowledge still exists especially for the practical application of electron beam technology and these are being addressed in other programmes.

Land applications of municipal sewage sludges are being practised throughout the world at different levels and their beneficial effects include increases in crop yields, soil organic matter, cation exchange capacity, water-holding capacity and fertility. High levels of nitrogen, phosphorus and micronutrients found in sewage sludges make it an excellent fertilizer. In addition, the high organic matter levels present can counteract harmful effects on soil structure.

Sewage sludges applied to crop plants besides providing macro- and micronutrients also contain heavy metals such as Cd, Cr, Ni, Pb, Co and Hg in amounts beyond those normally encountered in soils. A limiting factor for the use of sewage sludge, therefore, is the excessive accumulation of these heavy metals in soils and the resultant phytoxicity. Hence, fertility benefits must be balanced against the potential hazards of metal contamination through repeated applications of heavy dressings over long periods, and the use of sludges from industrial areas containing large quantities of heavy metals.

At present, information on the availability of nutrients from sewage sludges to crops, its benefits as an organic amendment to soil, and the harmful effects of heavy metals on crop growth, is limited. Isotope and radiation techniques could provide a valuable tool in attempts to find answers to some of these questions. As a beginning, a Consultants Meeting on "Radiation Processing of Sewage Sludge and its Use to Increase Crop Yields, and to Preserve the Environment" was held in Vienna, Austria at the IAEA Headquarters from 5 to 9 December 1994. The meeting was attended by 7 participants from 5 Member States and the staff members of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (RIFA), and the Soils Unit of the FAO/IAEA Agriculture and Biotechnology Laboratory in Seibersdorf. The list of participants is given in Annex 1.
2. OBJECTIVES

1. The overall objective of the meeting was to review the current status and future trends of the application of nuclear techniques in the use of sewage sludge in agriculture including:

   a) Radiation processing of sewage sludge by gamma irradiation, electron beam radiation and other alternative methods.

   b) Applications of sewage sludge as a fertilizer for increasing soil fertility and crop production.

   c) Heavy metal (Cd, Cu, Ni, Pb and Zn) contamination of agricultural soils.

   d) Potential harmful effects of sewage sludge utilization as a fertilizer on the agricultural environment, i.e., soil, plant, food, groundwater, water streams, etc.

2. To provide a critical evaluation of the topics to be investigated using nuclear and related techniques as well as prepare guidelines and workplans for the forthcoming CRP on "The Use of Irradiated Sewage Sludge to Increase Soil Fertility and Crop Yields, and to Preserve the Environment".

3. PRESENTATIONS AND DISCUSSIONS

   The meeting was formally opened by Mr. S. Machi, Deputy Director General and Head of the Department of Research and Isotopes, who after welcoming the participants, informed briefly about the mandate of the IAEA and the justification and objectives of the meeting. The meeting was organized in parallel with the Consultants Meeting on "Irradiation Treatment of Water, Waste-water and Sludges" of the Division of Physical and Chemical Sciences (RIPC). The opening session was also addressed by Mr. B. Sigurbjörnsson, Director of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Mr. R.M. Iyer, Director of the Division of Physical and Chemical Sciences, Mr. C. Hera, Head, Soil Fertility, Irrigation and Crop Production Section, and Mr. H. Vera Ruiz, Head of the Industrial Applications and Chemistry Section. Mr. K.S. Kumarasinghe, Scientific Secretary of the RIFA meeting and Mr. M. Lapidot, Scientific Secretary of RIPC meeting gave opening remarks.

   The opening session was followed by a joint session of the two consultants’ meeting, at which the main experts from the two groups presented overview papers of interest to both groups. The two groups then separated. Mr. Machi gave a special lecture on the industrial applications of radiation processing, at a joint session. The conclusions and the
recommendations, and the workplans were prepared separately by the two groups which were subsequently discussed at another joint session with the RIPCO group. This session was chaired by Mr. T. Lessel, who functioned as a consultant to both groups. The workplans were then finalized taking into consideration the comments from both groups.

The papers presented are given in the programme in Annex 2. S.P. McGrath (UK) presented a paper on long-term effects of land application of sewage sludge on the soil, microorganisms and plants. K. Kumazawa (Japan) presented a paper on the use of sewage sludge in agriculture in Japan. T. Lessel (Germany) discussed the work of the gamma irradiation facility in Germany while A. Suess (Germany) gave an overview on the potential harmful effects of sewage sludge utilization as a fertilizer on the agricultural environment. The paper presented by H. Harms (Germany) dealt with the use of nuclear techniques in studying the uptake and metabolic fate of sewage sludge derived xenobiotics in plants. The work carried out at the Bhabha Atomic Research Centre in Bombay, India was highlighted by K. Raghu (India). N. Hilmy (Indonesia) presented a paper on the evaluation of heavy metal content in irradiated sewage sludge, manure, and fertilized soil in Indonesia. F. Koch (Austria) informed the group about the utilization of sewage sludge in Austria. On Thursday 8th December, the group visited the Austrian Sewage Sludge Project in Mödling which was very informative.

4. CONCLUSIONS AND RECOMMENDATIONS

1. The Consultants meeting recommended that the Joint FAO/IAEA Division should coordinate a networked research programme with 12-13 contract holders from developing countries and 5-6 agreement holders from industrialized countries to assess the use of irradiated sewage sludge to increase soil fertility and crop yields in an environmentally sound manner.

2. The overall objectives outlined for the recommended programme are:

2.1. To assess sewage sludge, especially irradiated sludge, for its utility as a fertilizer and for increased crop production. Evaluate N and P uptake from the sludge under different soil and climatic conditions taking into account N and P losses, using $^{15}$N and $^{32}$P isotope techniques.

2.2. To assess the role of sewage sludge as an organic matter amendment to improve soil fertility, using neutron probes and gamma density probes, and isotopes, such as $^{14}$C, $^{13}$C and $^{15}$N.

2.3. To evaluate potential environmental contamination by:
Pathogens
Heavy metals
Organic pollutants
3. The meeting recommended that the networked research programme should compare data across diverse soil and climatic conditions with researchers using the same experimental treatments. More general recommendations will therefore be able to be made on the type of sewage sludge to use for specific crops in developing countries.

4. Close cooperation should be established between the joint FAO/IAEA Division and other organizations having active roles in the irradiation and utilization of sewage sludge in agriculture.

5. The findings of this programme should be published by the IAEA and made available as widely as possible.

6. The IAEA laboratories at Seibersdorf, in collaboration with the Austrian Research Centre, should conduct supportive research and training in the use of $^{15}$N, $^{32}$P, identification of pathogenic and beneficial microorganisms, using for example DNA probes, gene markers and other molecular biology techniques.

7. Reference laboratories and standard materials must be identified for the analysis of nutrients, heavy metals and organic pollutants.

8. All of the investigations must take account of the potential harmful effects on the environment: oil, plant, food quality, ground water and surface water quality. This is essential for the success of this programme and will be a contribution to sustainable agricultural development.

5. FOLLOW-UP

Based on these recommendations, 11 potential contractors and 5 agreement holders from Argentina, Austria, Bangladesh, China, Germany, Indonesia, India, Japan, Malaysia, Pakistan, Philippines, Portugal, Romania, Thailand, United Kingdom and the United States of America have been contacted and their applications now being processed. The first Research Co-ordination Meeting of the CRP on "The Use of Irradiated Sewage Sludge to Increase Soil Fertility and Crop Yields, and to Preserve the Environment" is planned to be held from 10-14 July 1995 in Vienna, Austria.
Annex 1

FAO/IAEA CONSULTANTS MEETING
ON
RADIATION PROCESSING OF SEWAGE SLUDGE AND ITS USE TO INCREASE
CROP YIELDS, AND TO PRESERVE THE ENVIRONMENT

5-9 December 1994

LIST OF PARTICIPANTS

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CONSULTANTS MEETING ON "RADIATION PROCESSING OF SEWAGE SLUDGE AND ITS USE TO INCREASE CROP YIELDS, AND TO PRESERVE THE ENVIRONMENT"
(Joint project with the Division of Physical and Chemical Sciences)

5-9 December 1994
Vienna International Centre, Vienna, Austria

Opening Session: Meeting Room A-1738
Other Sessions: Meeting Room A-2413

Scientific Secretary: K.S. Kumarasinghe (IAEA)

PROGRAMME

Monday, 05 December

09:00 Official Opening
(RIFA & RIPC joint session)

S. Machi
Deputy Director General and Head of the Department of Research and Isotopes

B. Sigurbjörnsson
Director, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

R.M. Iyer
Director, Division of Physical and Chemical Sciences

C. Hera
Head, Soil Fertility, Irrigation and Crop Production Section

H. Vera Ruiz
Head, Industrial Applications and Chemistry Section
Opening Remarks

K.S. Kumarasinghe
Scientific Secretary (RIFA meeting)
V. Markovic and M. Lapidot
Scientific Secretaries (RIPC meeting)

Session I  Chairmen  C. Hera (RIFA)/H. Vera Ruiz (RIPC)
(RIFA & RIPC joint session)

09:30
10.30 Coffee break
11.00
12:00 Lunch Break

A. Pikaev (Russian Federation)
S.P. McGrath (United Kingdom)

Session II  Chairmen  K. Kumazawa (Japan)/K. Krishnamurthy (India)
(RIFA & RIPC joint session - upto coffee break)

13:30
14:30
15:30 Coffee Break
16:00

T. Lessel (Germany)
F. Koch (Austria)
N. Hilmy (Indonesia)

18:00 Reception (Jointly with RIPC)

Tuesday, 06 December

Session III  Chairman  S.P. McGrath (United Kingdom)

09:00
10:00
11:00 Coffee Break
11:30
12:30 Lunch Break

A. Süss (Germany)
K. Kumazawa (Japan)
H. Harms (Germany)

Session IV  Chairman  H. Harms (Germany)

14:00
15:00
15.40 Coffee Break
16.10
16:50

K. Raghu (India)
K.S. Kumarasinghe (IAEA)
F. Zapata (IAEA)
G. Hardarson (IAEA)