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NUCLEAR SCIENCE AND TECHNOLOGIES IN COMBATING POVERTY

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by

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Abstract

Nuclear science and technologies are a useful and effective tool to solve and overcome many problems in human societies. Its applications are exploited in all human activities; agriculture and food, natural resources, medicine and public health, industry, energy... etc..
Gamma, X and Neutron radiation, isotopes, lasers, nuclear reactors are some of the major techniques widely used in daily life and contributed substantially to development and poverty alleviation.
Nuclear science and technologies though exploited in modern societies yet it is the beginning of their grand potential and more is expected if man uses his wisdom for the good of man on this earth.

1. Introduction

Human development during the history of mankind was the consequence of accumulated scattered knowledge gained by individual experience in human communities. It therefore took man kind more than 5 thousand years to put down the basis of scientific thinking. Thereafter the move towards knowledge was faster, and after 1400 years man was able to lay down the "scientific method" to search for knowledge rather than its accidental acquisition. The fruits of the scientific method in Europe brought the dawn of modern science after 700 years, however it was in the late 19^{th} century when modern science was well formulated and deeply rooted in all institutions of modern societies.

The exploitation and integration of modern science in the daily life of modern societies in such a way to serve their needs and ambitions brought up this giant form of production and technologies, upgraded their living standards and provided the accumulation of this fortune of wealth and knowledge. It is therefor the integration of knowledge in the daily life of human societies to serve their needs which brought about modern societies to what they are today and not only the acquisition of knowledge. Hence it is our turn in developing countries to stress on the need to deeply integrate the concept of modern science in our institutions and daily life of our societies. When I say so I don't mean the classical approach of our educational systems and institutions but I mean to spread the awareness among the people, authorities and even among the scientific communities for the need of innovative approach to serve the needs of our people.

Nuclear science and technologies though proved to be effective in serving human needs in all fields (e.g. Medicine, agriculture, industry... etc.) yet they are not exploited extensively in developing countries. It seems people are overwhelmed with the nuclear bomb hazards rather than the peaceful uses of nuclear technologies. Nuclear techniques were useful when other techniques failed to solve many problems and they were even less time consuming to provide solutions for many problems. The technologies when exploited and integrated properly to serve our development needs are expected to be effective in creating jobs and alleviating proverty in developing countries. Therefore it is useful to introduce briefly some of the most popular nuclear techniques utilized in major sectors of society for development and combating proverty.

2. Agricultural development

In the agricultural sector isotope aided (e.g. Nitrogen ^{15}N, Phosphorus ^{32}P... etc.) fertilizers helped to rationalize the rates of applied fertilizers.Isotope tracers improved our understanding of nutrients dynamics in the soil - plant systems which improved land and plant productivity. Neutron gauges used to monitor soil moisture dynamics reduced water loss by excess irrigation and ground water contamination with leached pollutants. Discrimination of $^{13}C/\ ^{12}C$ in plants, could be used as a measure of water use efficiency, helps to select plants of higher efficiency in water use for dry areas. Isotope tracers such as ^{14}C are also used to study the fate of pesticides and their residues in food, plants, soil, water and animals and its implications on public health and the environment.

Gamma (γ) irradiation of plant seeds stimulates plant growth and production and induce plant mutants to overcome environmental stresses and resist diseases. These mutants when combined with biotechnology (induction, isolation and selection in vitro) could reach the required plants within 6-12 months rather than 4-7 years by classical ways. Crops are protected by controlling or eradicating insect pests (e.g. fruit flies) by

applying sterile insect technique (SIT) or inherited sterility technique (I.S.). Irradiation is also used to improve the nutritive value of animal protein by - products, and available agricultural residues to be used in poultry rations and ruminants diets respectively.

Radioimmunoassay techniques are used to improve the productive and reproductive performance of livestock (determining the reproductive hormones characterizes the different stages of reproduction) which would help to control animal rebreeding without delay and consequently increase the production of meat, milk ... etc.. Tritiated water is used to relate animals metabolism to environmental factors to identify efficient species and breeds and management techniques to improve animal production from marginal grazing lands.

ELISA techniques have been implemented for surveillance of many materials, compounds and animal diseases (e.g. rinderpest and PRP) which would help farmers and animal owners to save their herds.

All the above mentioned techniques increase plant and animal production, improve its quality and reduce the cost of production which would increase national income on country basis, individual farmers income on community basis and reduce the cost of living by providing good and cheaper products. New mutants (e.g. salt tolerant plants and new economic plants) also enables the beneficial use of saline soils and water, adding a new source of national income and help individual farmers to improve their income.

3. Food preservation

Around 60% of crops production is consumed by human societies and the rest is lost during storage and marketing.Thus several techniques including nuclear ones are implemented to preserve these products and other food.

Post harvest irradiation of agricultural products by low doses ($\leq$ 1 k Gy) of Gamma radiation, X - ray or Electron beam could reduce losses of stored food by controlling insect pests (on grains, fresh and dried fruits, dried fish and meat), inhibiting germination of seed bulbs (e.g. onion and garlic), and sprouting of seed tubers (e.g. potatoes) and extend the shelf life and storability of fresh fruits and vegetables by depressing its physiological activities such as respiration, and maturation. Irradiation with moderate doses (1-10 k Gy) extend the shelf life of fresh meat (fish, chicken.. etc.), frozen meat, sea food and dried fruits and vegetables by controlling the infectious microorganisms. High doses (10-50 k Gy) of irradiation are used to sterilize ready meals, enzymatic compounds and natural peppers. The outcome is therefore more, healthier and cheaper food available to people.

4. Natural resources management

Intensive misuse of natural resources (water, vegetation and land) during the history of human societies diminished plant cover, degraded land and exhausted water resources especially in dry areas where ecosystems are fragile. Degradation of natural resources in many countries forced people to migrate to cities or towns or even to other countries searching for their living, exerting pressure on developing plans of cities and towns and creating bad living conditions.

Sustainable management of these resources is indeed the solution to conserve them. However their rehabilitation and improving their productivity is required to satisfy the increasing demand of the growing population. The first step to do so is to assess their potential and this could be done effectively by available nuclear techniques.

Soil erosion hazards from sloppy lands could be assessed by determining the redistribution (vertical and horizontal) of radionuclides in soils. Determining the concentration of Cesium ^{137}Cs in soil provides information about the state of degradation during the last 40 years. Measuring the concentration of lead ^{210}Pb in soils helps to asses on going losses of soil whereas measuring Beryllium ^{7}Be would asses eroded soil from the top 1 cm surface. The combined measurements of these radionuclides would give an overview of what could have been the state of land 40 years ago and what further degradation may occure. This information, once coupled with plant cover studies, enables the assessment of the landscape potential in the areas concerned.

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Isotope hydrology studies water resources, their origin, dynamics, cycle, age and water balance by determining 4 major isotopes in rainfall and ground water; Carbon ^{14}C, Tritium ^{3}H, Detrium ^{2}H and Oxygen ^{18}O. Carbon ^{14}C dating of ground water for example in the Syrian stepp area (AL- Badiah) showed that the age of water goes back to 12,000 - 20,000 years ago and that the climate was at that time cooler by 6°C than it is today, indicating that a major part of the accumulated deep ground water occurred in that period. This information defines the capacity of ground water, the renewable amounts, the annual and seasonal charge and discharge of ground water. Thus the potential of available water could be assessed and the plans for its use in sustainable manner would be set up. Also these techniques helps to determine the origin of ground water salinity (e.g. The Euphrates Basin in Syria).

Screening Forage legume plants according to their efficiency in symbiotic nitrogen fixation by measuring the differences in their nitrogen ^{15}N natural abundance enables the exploitation of more efficient plants to overcome some nutritive deficiencies in degraded lands and low fertile soils. The technique could also be used by microbiologists to screen more efficient rhyzobium strains in nitrogen fixation and enhance their exploitation to improve soil fertility.

5. Geology and mining

Detection of radionuclieds radiation activity helps to discover the natural deposition of some important elements and to asses their economical mining or the mining of their associated compounds (e.g. Uranium, Phosphate rock ...etc.). Also the technique is a useful tool to study the neotectonics and the associated hazards of earthquakes such as detection of Radon ^{222}R emissions in active tectonic zones.

Discovering elemental deposits for mining adds more sources of national income and creates more job opportunities. The early warning of possible earthquakes occurrence by ^{222}R detection reduces socioeconomic losses and disruptions.

6. Medicine and public health

Nuclear techniques has an important role in diagnosing, curing and controlling human diseases and disorders. Neutron radiography, X- ray, Nuclear magnetic resonance ... etc. are a break through in diagnostic medicine for their effective imaging of human tissues and diagnosing the state of deformation and disorders e.g. bones, muscles and other organs in human body. Radioisotopes (Technetium $^{99}Tc^{m}$, Iodine ^{131}I, Fluorine ^{18}F... etc.) are tools for in - vivo imaging to enable an early diagnosis of many diseases in the heart, brain, kidneys, entrogastric, glands.. etc. of humans. In - vitro diagnosis applies many nuclear techniques in particular Radioimmunoassay (RIA) to quantify hormones and biochemicals in blood circulation and the different bioliquides. Besides the technique determines many tumor markers in blood serum to follow up and diagnose tumors.

Radioisotopes are also used to treat many diseases particularly tumors by either using seald sources (e.g. ^{60}Co gamma radiation units or ampoules of radionuclides implanted in tumors) or unseald sources e.g. intravenous injection or oral intake of ^{131}I to treat some thyroid gland diseases. Phosphorus ^{32}P, ^{153}Sm, ^{165}Dy are used to treat lymphatic and dermatic systems, bone cancer and bone joints respectively. Boron neutron capture therapy is another technique to treat some cancer diseases.

A major contribution of gamma radiation (SIT) was to control two epidemic diseases caused by the tsetse fly and the screwworm and still it is the most effective adopted method. The technique is also used to sterilize medical tools e.g. disposable syringes, bandages, surgical tools.... etc.. Neutron beam scattering is another technique used to study viruses structures opening ways to develop methods to control their infectious effects.

Lasers too are extensively used in ophthalmology (eye surgery) where Argon laser treats complications of diabetes in the retina, Yag laser cleans the posterior capsule of the lens after cataract surgery and Xymer laser corrects the refractive error of the eye especially myope.

Improving health services and controlling epidemic diseases will create job opportunities and improve the health conditions of the people which in turn will improve their productivity and consequently their income.

7. Industry

Petroleum and engine industries and power plants extensively use industrial radiography by Gamma, X, and Neutron rays to detect corrosion, erosion, deposits and blocking of pipes, hidden or seald surfaces of engines ... etc.. The techniques enables measurements during operation, without removing insulations and paints, on complex parts and without destroying or dismantling the parts. In the oil industry they assure the detection of many kinds of flows in the components of products during production and testing. They also provide permanent records and by periodic examination the rate of corrosive attack could be measured.
Neutron reactors are utilized in many fields of production; Neutron scattering is used to test material characteristics and development e.g. polymers, semi and super conductors, Radioisotopes (^{82}Br, ^{24}Na,^{192}Ir, ^{140}La, ^{90}Y, ^{64}Cu, ^{166}Ho...etc.) are also produced by the reactor to be used in industry, medicine, agriculture... etc..

Thus industrial observations of corrosion, cracks, erosion ... etc. avoid economical loss due to causes of fire, leaks, reduction in production and costly shutdowns for repair and replacement. Producing isotopes will also have an indirect economic role in other fields of human activities and improves national and community income.

8. Chemistry

Instrumental neutron activation analysis (INAA), X-ray fluorescence (XRF), X -ray diffraction, Gamma spectroscopy, Mass spectroscopy and liquid scintillation counting (LSC) are sensitive techniques used to detect elements and isotopes in biological, water, air, soil, geological, archaeological and synthetic samples. The analysis of which is of important use to control environmental hazards, public health and industrial and agricultural products and has an indirect substantial economical input to products marketing and environmental management.

9. Energy

Nuclear reactors proved to be an attractive and effective alternative source of energy to satisfy the increasing demand for heat and electricity in modern societies and developing countries. It has the advantage of reducing environmental hazards implied with the use of fossil sources of energy. It is therefore increasingly exploited in many countries and its contribution to energy supply is substantial in countries like France (76%), Japan (36%), Germany (28%) and the United States of America (19%), whereas it is neglected in developing countries and is not more than 1.2% in China and 2.5% in India.

However with the increasing depletion of fossil sources the need for nuclear energy is increasing. Besides fossil sources has other important uses in modern and high technologies than to burn for energy.

Expectations of energy demand i.e. in Syria is increasing and fossil sources will soon be inadequate to satisfy our demand. Nuclear energy is therefore the expected source we could rely on. Besides it could also be used for sea water desalination, a source of water may be needed to satisfy our increasing demand for water. However the reactor will not only supply energy but it may be a focal center to develop required expertise in nuclear science and its applications on national and regional bases.

10. Concluding remarks

Nuclear science and technologies could be more effectively exploited in all human activities and its uses today are only the beginning utilization of the unlimited horizons it holds for development. Its peaceful uses will prove that it holds the future of human societies.

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