DEPLETING STATE OF STRATOSPHERIC OZONE: A CHALLENGING CONSERVATION FOR GLOBAL COMMUNITY WITH SPECIAL REFERNCE TO ERITREA

Mohammad Afsar Alam
PhD., Assistant Professor and Ex-Head
Department of Geography
Adi-Keih College of Arts and Social Science, P.O.Box 59,
Eritrea, N.E. Africa,
e-mail: drmaalam92@gmail.com

UDK: 504.05:916
COBISS: 1.02

Abstract

Depleting State of Stratospheric Ozone: A Challenging Conservation for Global Community with special Reference to Eritrea

Though the basic needs of the humans are prioritized first, health and quality of environment are also equally important. Environmental issues are based on many and different things. One of these is the depleting state of Stratospheric Ozone in the atmosphere. The ozone layer is vital to life on earth because it acts as a filter for UV radiation, which can have severe impacts on human health and the earth's environment. As estimated, every one per cent decrease in the ozone layer results in the increase of ultraviolet light intensity at the earth's surface by two per cent. Known effects of ultraviolet exposure include greater incidence of skin cancer and eye cataracts among humans and diminished crop yields for foods such as peas, beans, and squash and soya beans. Phytoplankton, the tiny one celled Ocean plants that are staple food for squid, fish, seals, and whales also are vulnerable to Ultra violet radiations. Depletion of ozone layer is one of the main issues of the world today. Concerning to these issue two important meetings had been hold i.e. known by the Montreal Protocol and Vienna Convention. Most of the world countries are part of this Montreal Protocol and Vienna Convention. Eritrea is also part of Montreal Protocol and Vienna Convention. In the present paper basically an attempt has been made to show the world's concern in general and the Eritrea's in particular about the conservation measures taken on mitigation of Ozone layer. This research paper also emphasizes on the global problem of Ozone Depleting Substances (ODSs) releasing from different industries and specific sources. Besides, the study further includes the existence of naturally created Ozone hole on the Polar Regions.

Key words

Ozone layer, Depletion, Chlorofluorocarbons (CFCs), Environment

Uredništvo je članek prejelo 15.11.2016

1. Introduction

The term ozone layer describes the zone of the highest concentration of ozone molecules in the stratosphere. The layer, which is 10–20 km thick, envelopes the entire globe like a bubble and acts as a filter for the harmful ultraviolet (UV-B) radiation produced by the sun. The stratosphere is the part of atmosphere above the troposphere. It starts at 15–30 km above ground level and continues up to 40–50 km.

Stratospheric ozone differs from ground-level ozone. Ground-level ozone is created both by natural process of percolating of broken ozone molecules from the stratosphere and also, from industrial and traffic emissions. It is part of photochemical smog, and, as an irritant gas, it may cause human respiratory problems, especially in older people and young children, as well as damages plants. The ozone layer is vital to life on earth because it acts as a filter for UV radiation, which can have severe impacts on human health and the earth's environment.

Stratospheric ozone filters out dangerous ultraviolet radiation by means of a continuous cycle in which oxygen and ozone, break down and reform, absorbing ultraviolet light and releasing less damaging kinds of energy. Without enough ozone, the effectiveness of the filtering capacity of ozone decreases and more ultraviolet radiation reaches the earth. The main destroying causes for the stratospheric ozone are a group of chemicals known as chlorofluorocarbons (CFCs) and halogens, which are produced by humans and released into the atmosphere. These substances are very stable and remain unchanged in the lower layer for as long as a century. During their long lifetime, the CFCs and halogens drift up to the stratosphere where they are exposed to high-intensity ultraviolet radiation and breaks apart. CFCs release highly reactive atoms of chlorine, halogens and bromine atoms. The chlorine and bromine atoms are very reactive in breaking up ozone and tying up oxygen atoms that might form new ozone.

According to the Scientists, a single chlorine atom can destroy up to 100,000 ozone molecules before the chlorine is finally captured by a reaction with hydrogen. One bromine atom can destroy nearly ten times as chlorine atom. Even if production of CFCs and halogens ceased tomorrow, the full destructive effect on the ozone shield would still be felt for years into the future. Even now, releases over the past several decades of the long-lived chemicals are making their way up toward the stratosphere. Other threats to the upper ozone come from chemicals found in certain degreasers, adhesives, dyes, pesticide, aerosols and fungicides.

2. Objectives of the study

The present study has manifold objectives. One of the objectives of this study is to have better knowledge and understanding about the structure of ozone in the atmosphere, phasing out the depleting chemical substances and ozone protection processes. Besides the above objective, the other important objectives of the study are given as follows:

- To provide knowledge and understanding of the structure of ozone molecules and their distribution in the atmosphere.
- To review the processes of how Ozone hole is created, the effects of the ozone depletion on ecology including human beings; and measures of mitigating the problem.

- To assess the role of Eritrea in the mitigation of the Ozone depletion or evaluating Eritrea on the process of Ozone layer protection.
- To identify the role of inspection of the projects that has been used to reduce Ozone depleting substances (ODSs), and finally
- To foresee the future trends of progress.

3. Methodology

The study has been accomplished through both the primary and secondary data which have been collected from various sources. The primary data are collected from government offices of Ministry of Land, Water and Environment; Department of Environment and also from refrigerant workshops. For the acquisition of primary data two methodologies have been employed i.e. discussions and interviews, discussions with the Head office of the Department and interviews with the refrigerator technicians.

The secondary data are collected from published books and unpublished softcopies which are sourced from internet and software. These sources of data include reports and proceedings from the Ministry of Land, Water and Environment (MoLWE). The information are gathered from various respective sources; they are compiled, processed, analyzed, illustrated and presented in figures, charts, graphs and tabular forms. Computation of data is followed by cartographic representation and analytical notes. Apart from these a number of articles published in various National and International journals have also been consulted for the purpose.

4. Background Literature

Eritrea is one of the east African countries located in the horn of Africa. It sprawls between 12° to 18° north and 36° to 44° east, is bounded by Red Sea in the northeast and east, by Djibouti in the southeast, by Sudan in the north and northwest and Ethiopia in the south. Review made on documents indicates that no doubt, Eritrea is one of the highly backward countries of the world, even though she is aware of the significance of ozone layer and its depletion. The present study reveals that Eritrea ratified the Vienna Convention and the Montreal Protocol on the 2nd of March 2005 and all four amendments on 27th June in the same year. However, Eritrea had already realized the problems associated with Ozone Depleting Substances (ODSs) on Human health and other life forms well before it ratifies the convention. As first step to address the concern, Eritrea through the Department of Environment of the Ministry of Land, Water and Environment (MoLWE) has undertaken nationwide inventory of ODSs and ODSs based equipment in 2002 (Albritton, Daniel 1998).

Although Eritrea produces and consumes minor amount of any of the substances controlled by the Montreal Protocol, it is very vulnerable to the effect of ozone layer depletion and climate change (Some ODSs are also greenhouse gases). Eritrea's consumption is mainly on refrigeration and air conditioning.

The review further shows that the ratification of the Montreal Protocol on Substances that Deplete the Ozone Layer, Eritrea has accomplished several tasks to ensure effective implementation of the Convention and Protocol by adopting the following measures:

- Establishment of the Ozone Unit office to facilitate the works

- Promulgation of the legal notice for issuance of licensing system for the importation and exportation of ODS and ODS based equipment
- ODS and ODS-based Equipment Survey (2005-2010)
- Phased-out all CFCs
- Undertakes annual assessment to determine the annual Prepares.

Distributed several Refrigeration and Air-conditioning equipment to Private and Public institutions. This will assist technicians and refrigeration sectors perform safer maintenance for effective recovery of ODS and ultimately eliminates the release into the atmosphere. Based on these literatures, we are going to assess Eritrea's role in terms of its adopted strategies, regulations and promulgations as well as awareness rising actions.

5. Global Distribution of Ozone

Ozone is not uniformly found across the globe. The total ozone varies with latitudes, longitudes and seasons. High amount of Ozone concentrations is found in high latitudes, and the lower latitudes have lowest amount of Ozone concentrations. This is caused by winds that move from tropical region toward the poles. Moreover, high latitudes have large amount of ODSs gases concentrated due to the characteristics of the gases that move and condensed in the cooler area of high latitudes. These ODSs gas make chemical reactions with clouds in winter season. This chemical reaction affects the ozone molecules which result in low amount of concentration of ozone in high latitudes. Total ozone concentration is measured by Dobson unit (DU) through local and remote techniques. Local measurement requires light weight ozone measuring modules suitable for launching on small balloons (Environmental Science and Technology, Vol 28, no. 13 1994). It also uses optical detection or research aircrafts. In remote measurement ozone abundance is measured by detecting the presence of ozone at distances away from the place by using instruments in satellites.

6. Formation of Ozone Hole

The severe depletion of the Antarctic ozone layer known as the "ozone hole" occurs because of the special weather conditions that exist only there and nowhere else on the globe. The very low temperatures of the Antarctic stratosphere create ice clouds called polar stratospheric clouds (PSCs). Polar stratospheric clouds cause changes in the relative abundances of reactive chlorine (D. H. Stedman 1981). Reactions occur on the surfaces of PSC particles during wind turbulences in winter. This disintegrates the reactive chlorine compounds, ClONO2 and HCl, to the most reactive form (Washington, DC: National Academy Press 2008). ClO become active in the chemical destruction of ozone when sunlight is available. As a result of this, the ozone layer gets thinner and creates ozone hole.

According to an estimate, every 1 per cent decline in stratospheric ozone concentration translates into a 2 per cent increase in the intensity of biologically active ultraviolet rays that passes through the ozone layer (Washington, DC. 1989). Increased propagation and overexposure of ultraviolet rays may cause not only serious human health problems but it will affect the other mammals too. Its harmful effects may include a greater risk of skin cancer in human and animals, eye damage including cataracts, immune deficiencies, and reduction of crop yields and destruction of certain forms of aquatic life. Higher dosage of ultraviolet rays lead to reproductive failure also particularly in birds and lizards and hence threaten the ecosystem.

Since 1967, the amount of ozone in the stratosphere has decreased by about two per cent. Ozone hole is in fact not a hole, but it is a dark patch in the ozonosphere over the Antarctica. For this dark patch the use of Chlorofluorocarbons (CFCs) is exclusively responsible. The first indication of a thinning of the ozone shield above Antarctica was discovered by Joe Farman, Jonathan Shanklin and Brain Gardiner in the mid-1980s. Ozone hole is created as well as recovered by natural phenomena. During the southern hemisphere Spring (mainly September and October) every year the ozone layer in the Antarctica thins drastically. But by November or December at the latest, the ozone level recovers naturally (Monthly Weather Review vol. 101 2005, 426–443). The area of ozone depletion over the Antarctica is known as 'Antarctic ozone hole', is as big as the size of United States of America. It is estimated that up to eight per cent of the protective ozone layer over the United States, Canada and Europe has disappeared. Researchers report that the seasonal "hole" over Antarctica and some populated regions of the Southern Hemisphere thins the ozone layer at times by as much as 60 to 70 per cent. This seasonal hole is created by summer and winter season. So, we care about Ozone because of the importance of its presence and the negative consequence as it gets depleted. Among the countries affected by ultraviolet radiation, United States of America is the worst victimized. According to a survey more than 400,000 new cases of skin cancers are diagnosed each year; about one in seven Americans will develop this disease during their life time.

Initially, the chlorofluorocarbons (CFCs) was synthesized around 1928, later, in 1970 scientists found that the Ozone depleting substances (ODSs) deplete the ozone layer. Consequently in 1977, the United Nations for Environmental Programme established a coordinating committee on the ozone layer, comprising the world's leading experts, to study the problem and suggest solutions. So, Diplomatic discussions started on the major global environmental issues. The first Convention, known as the Vienna Convention held in1985 drew up a framework for studying ozone depletion in more detail. But the Convention was not successful due to some drawbacks in controlling the production and consumption of ODSs. Especially on the part of industrial sectors there was unwillingness as they produce and consume too much amount of ODSs. As a result, Vienna Convention and the Montreal Protocol came into existence just after two years, on 16th September 1987. This protocol strengthened progressively by a number of adjustments and amendments (Andelin and John 1988).

In recognition of the protocol's unique accomplishments, the UN General Assembly announced the September 16, as the international day for the preservation of the ozone layer. All members of the protocol celebrated the international ozone day. Scientists, Paul Crutzen, Mario Molina, and Sherwood Rowland received the Nobel Prize in 1995 for their contribution on the chemistry of ozone layer.

A number of institutions and procedures have been established to assist the smooth working of the Montreal Protocol and Vienna Convention .As mentioned above, the mitigation strategies are not a matter for developed states only as it also involves developing states because it requires the aggregate work of states for better achievement of the objectives of the protocol (Washington, DC 1995).

Eritrea is part of Vienna Convention for protection of the Ozone layer and the Montreal Protocol which aims at phasing-out the ODSs that deplete the ozone layer. It plays a vital role. Eritrea ratifies Vienna Convention and Montreal Protocol on 2nd march 2005 under the responsibility of Ministry of Land, Water and Environment. For this purpose,

Eritrea established separate departments who care about the Ozone affairs. Even before, Eritrea had been playing a considerable role in such issues.

7. Common Ozone Depleting substances (ODSs)

The common Ozone-depleting substances (ODS) are chemical substances like chlorinated fluorinated or brominated hydrocarbons have the potential to react with ozone molecules in the stratosphere. If a substance is only fluorinated (does not contain chlorine and/or bromine), it is not an ozone-depleting substance. ODS include:

- Chlorofluorocarbons (CFCs)
- Hydrochlorofluorocarbons (HCFCs)
- Halons
- Hydrobromofluorocarbons (HBFCs)
- Bromochloromethane
- 1, 1, 1-trichloroethane (methyl chloroform)
- Carbon tetrachloride
- Methyl bromide.

According to reports, in most developing countries like Eritrea, most of the ODS are still used in refrigeration and air-conditioning. CFCs and HCFCs are used as refrigerants for the cooling circuits. ODS are also used as blowing agents for foam applications, as cleaning solvents in the electronics industry and in dry-cleaning, as propellant in aerosol applications. As sterilants in hospitals Metered-dose inhalers (MDIs) used for treating pulmonary diseases and fire-fighting agents. Moreover, use as fumigants for controlling pests. ODS can be applied in laboratory as analytical reagents.

Tab. 1: Shows ODSs occurrences in percentage across the world.

Occurrences of CFCs and HCFC from different sources	Percentage of Occurrences
Refrigerant and Air Conditioning	30%
Foam Products	14%
Solvent Cleaning Products	36%
Aerosols	5%
Sterilization	3%
Others	12%

Source: Ministry of Land, Water and Environment, Department of Environment.

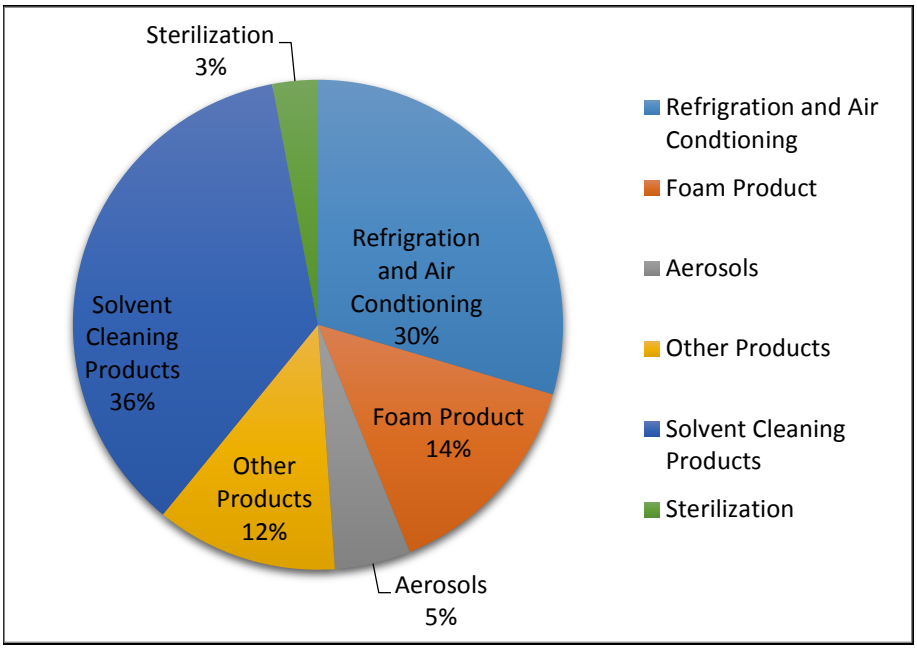

Fig. 1: ODSs occurrences in percentage across the world.
Source: Ministry of Land, Water and Environment, Department of Environment.

The above table and pie chart shows the occurrences of ODSs in different products. Solvent cleaning products produced a great deal of ODSs comprises almost 36 per cent of the total ODSs produced. Refrigerant and air conditioning, Foam products, Aerosols, sterilization and others sources comprises 30, 14, 5, 3 and 12 per cent respectively.

8. Impact of Ozone Depletion on Human Health

Ozone's unique physical properties make the ozone layer to act as our planet's sunscreen, providing an invisible filter to help protect all life forms from the Sun's damaging UV rays. Most incoming UV radiation is absorbed by ozone and prevented from reaching the Earth's surface. Without the protective effect of ozone, life on Earth would not have evolved the way it has. The ozone layer protects us from the harmful effects of wavelengths of ultraviolet UV light from the Sun. The danger to human health from ultraviolet radiation comes mainly from the UV range of the spectrum. Any significant decrease of ozone in the stratosphere would result in an increase of UV radiation reaching the Earth's surface, and cause health problems. Some of the possible harmful effects of increased UV light on human health include:

- Skin cancer
- Immune inhibition
- Cataracts

8.1 Skin cancer

The most well-known effect of UV radiation is the slight reddening or burning of the skin when exposed to sunshine. This change of colour is caused by an expansion of the skin's blood vessels. For most people burning is followed by tanning within a

couple of days. A permanent tan will occur when the UV radiation causes a pigment called melanin to form in the pigment cells of the skin. Over a period of years, exposure to radiation originating from the sun cause damages in the skin's connective tissues, so-called photo-ageing. This manifests itself as a thickening of the skin, as wrinkles, and reducing of elasticity. Elastin and collagen fibres determining the firmness and elasticity of the skin are damaged. UV radiation thus increases the risk of getting skin cancer.

Research has shown that even small amounts of UV radiation can cause considerable harm. UV damages the genetic material of DNA and is related to some types of skin cancer. It is important to note, that UV radiation has always had this effect on humans. In recent years non-melanoma skin cancer has become more prevalent in many parts of the world because people are spending more time in the Sun and are exposing more of their skin in the process.

The relationship between the occurrence of milder non-melanoma skin cancers and time spent in the sun is well documented. Such cancers generally occur in people in their 70s and 80s on areas of the skin usually exposed to sunlight (such as the face or hands). Malignant melanoma (another form of skin cancer), however, usually occurs in younger people and in skin areas not necessarily exposed to sunlight. It tends to occur most commonly among groups of people less likely to have spent significant amounts of time outdoors.

The risk of developing malignant melanoma is directly related to the sensitivity of an individual's skin to the sun. Fair-skinned is more susceptible than darker skinned individuals. The victims are almost exclusively Caucasians, particularly fair-skinned Caucasians. The incidence of malignant melanoma has been increasing among light-skinned populations around the world for decades. An increase in the levels of UV reaching the Earth as a result of ozone depletion may compound the effects of spending more time in the sun. According to some estimates, a sustained 10 per cent global loss of ozone may lead to a 26% increase in the incidence of skin cancers among fair skinned people. Australia, with high sunshine levels, has very high skin cancer rates. Estimates show every two of three people in most parts of the country develops some form of skin cancer. In Queensland, where UV radiation is the highest, the probability jumps to three in every four people.

The evidence for UV being a causative factor in skin cancers are as follows:

- The cancers are most often found on areas of the body exposed to the sun.
- The incidence is higher in people with outdoor occupations.
- The incidence increases with age.
- Conclusions are supported by studies on mammals.

8.2 Immunological Effect

Skin is an important immunological organ; the immune system is vulnerable to modification by environmental agents, including UV radiation. Demonstrations that immunity can be disturbed by exposing skin to UV radiation raise the concern that ozone depletion might adversely influence immunity to infectious diseases.

8.3 Cataracts

UV radiation can damage the cornea leading to snow blindness. Symptoms of this kind of an infection include the eyes becoming reddish, a sensitivity to light, enhanced excretion of tears, the feeling of having some dirt in one's eye, and pain. A long-term

exposure to UV radiation increases the dimming of the eye's lens, which means that potential cataracts begin to evolve at earlier ages. A cataract is a partial or complete opacity (not allowing light to pass through) of the lens of the eye and is the main cause of blindness in the world. Part of the UV radiation reaches the back of the eye, causing cells in the retina to slowly begin to deteriorate. Damage will in time particularly occur to near vision. If not operated upon blindness can occur. Radiation is partly absorbed in the lens of an adult eye, but will go right through the lens of a child, reaching the back of the eye. For this reason, children's eyes in particular should be protected against strong sunlight.

Other common eye diseases associated with increased UV radiation are eye cancer, conjunctivitis and pterygium. Conjunctivitis is an inflammation of the membrane covering the anterior portion of the eyeball. Pterygium is a thickening of the membrane that covers the eyeball. Increased exposure to UV radiation from ozone depletion is expected to increase the number of people experiencing cataracts. A 1 per cent decrease in stratospheric ozone may result in 100,000 to 150,000 additional cases of blindness due to eye cataracts world-wide.

9. Impact of Ozone Depletion on Environment

Other than effects to human health there are other impacts which could result from prolonged destruction of ozone in the stratosphere. Our environment and all living things within it are affected by this harmful radiation. UV rays also brings damage to polymers used in buildings, paints and packaging, and changes in biogeochemical cycles affecting ground-level pollution (smog), acid rain and even climate change. Animals and plants life, the land vegetation and aquatic life is highly damaged by a prolonged exposure to UV radiation.

10. Government Strategies and Regulations to Phase out ODSs in some countries

The Norwegian government adopted an action plan early in 1988 to reduce the use of CFCs by 50 per cent by 1991 and 90-100 per cent by January 1, 1995. This early action plan served as planning guideline for the industry, particularly because it later proved to be in good accord with international agreements to phase out CFCs. Its existence made it possible for industry to make the transition from CFC technology relatively easily and efficiently (Norway; government strategies; UNEP 1997, 19).

The legal methodology chosen was a regulation banning almost immediately all imports, production and exports of CFCs and halons unless a special exemption was issued by the Norwegian state pollution control Authority (STF). This regulation, dated January 1991, also prohibits imports, sale and sometimes use of CFC and halon related products without an exemption from the SFT, with scope and dates specified for each application sector.

In addition, Norway provided substantial financial support to the trade associations so that they could provide information and technical assistance to contractor’s and equipment owners, as described below.

10.1 Regulations on CFC and HCFC supply

The SFT implemented the ban on CFC imports by estimating the requirement for each chemical, and then assessing the costs, available alternatives and technical

competence needed to phase out its use. Import permits for CFC-12 and CFC-115, the main CFC refrigerants, were therefore reduced more slowly than for other CFCs. Since 1995, no import permits have been issued for CFCs (Norway; government strategies; UNEP 1997, 20).

10.2 Regulations on new equipment using CFC refrigerants
The 1991 regulation also prohibits the production, import, export, installation and sale of refrigeration, air-conditioning and heat pump equipment with CFC refrigerants. The SFT based the implementation of this ban on discussions with industry and experts regarding available alternatives and competence, as well as the costs of phasing out CFCs and introducing alternatives. Exemptions for new equipment have been progressively refused, with the largest units being phased out first. Imports of units containing less than 1 kg of refrigerants (such as domestic refrigerators) - the last category to be allowed- have been refused since 1 July 1993.

The SFT received a total of 400-500 applications for exemptions during 1991-1992.During this period 3-4 persons worked on ODSs issues, reviewing applications for exemption, preparing additional ODSs regulations included consequence analysis, attending meetings, reporting to the ozone secretariat and providing information services (Norway; government strategies; UNEP, 1997, pp.20).

10.3 Regulations on HCFCs in new equipment
In 1997, restrictions on HCFCs in new equipment were under preparation, closely following those applicable in European Union countries.

10.4 Regulations on installed equipment using CFC and HCFC refrigerants
The 1991 regulations contained a general clause compelling anyone who handles CFCs to acquire the knowledge needed to reduce unnecessary emissions. Technicians installing or servicing equipment containing CFCs must therefore ensure that CFCs are not emitted to the atmosphere. The compliance is controlled within the framework of the SFT's general pollution control, supported by some information from the public. The 1991 regulation empowers the SFT to select a deadline for phasing out the use of CFCs in existing refrigeration; air- conditioning and heat pump equipment, taking into account the costs and technical alternatives available. Due to the high cost and lack of technical capacity in replacing existing refrigeration equipment with CFCs and HCFCs, STF has not yet decided any date for prohibiting the use of CFCs and HCFCs in existing equipment.

The regulation also empowers the SFT to requires that a code of practice is followed and that all servicing of equipment using CFC refrigerants, including recharge and recovery, is carried out only by authorized enterprises or certified people. The SFT has decided not to put these restrictions into operation and to rely, at least for the time being, on market forces to phase out the use of CFCs refrigerants in existing equipment, in line with the declining supply of virgin and recovered CFCs which is resulting from the ban on import of virgin substances. The main reasons for this decision were:

- The SFT considered it impossible to ensure that authorized companies really followed the authorized procedures.
- Allowing the trade association to administer an authorization scheme would imply transferring powers to the private sector that would normally rest with government authorities; in any case, the possibility of appeal would be necessary.

11. Awareness Raising Activities

The Norwegian government has tried to raise awareness among refrigeration technicians and equipment owners of the actions needed to phase-out the use of CFCs, with financial support from the government (NOKI 1.45 Million). This includes a country wide inventory of existing refrigeration equipment, a manual for conversion from CFC-12 to HFC-134a, seminars and brochures for equipment owners-particularly in the retail sector. Those brochures highlight the risks involved for owners of CFC equipment when the CFC supply vanishes. They also contain detailed recommendations on how owners should make an inventory and evaluation for their equipment, prevent leakage and plan for conversion to other refrigerants.

12. Institutional Framework and National Polices

12.1 National Level Institutions

The Government of the State of Eritrea had outlined the ozone related Policies, institutional and legal frameworks. In addition practical measures to conserve and mitigates ozone layer supported by various programs and projects. These legal and institutional instruments are briefly described below.

In general term, relevant Ministries directly lead environment conservation, development and management aspects. Their primary roles contain regulatory function, monitoring and evaluation, research and training.

The Ministry of Land, Water and Environment is the main player for environmental and natural resource management in Eritrea. The Department of Environment (DoE) of the Ministry of Land, Water and Environment (MoLWE) has responsibility for monitoring the state of the environment.

The Ministry of Trade and Industries has a mandate to regulate and control the importation of ODSs with close cooperation with the Ministry of Land, Water and Environment.

The Ministry of Energy and Mines (MoEM) has a development policy and strategies that promotes economically and environmentally sound energy sector development. The Ministry of Energy and Mines has the responsibility to collaborate with Ministry of Land, Water and Environment to present annual uses of ODSs in their sector in all mine sites such as Bisha mine site, Zara mine site etc.

The Ministry of Health (MoH) has responsibility to cooperate with Ministry of Land, Water and Environment for importation substitutes of HCFCs gases, as most of the hospitals use cooling equipment.

The Ministry of Information (MoI) has the role to propagate and to broadcast information that aims to raise the awareness on equipment that contains ODSs.

Industries: All industries use high amount of refrigerants for their cooling systems. Some of those sectors include Red Sea Bottlers, Dairy factories, Asmara Brewery Factory, Massawa ice chillers factory and all mining private sectors. These sectors cooperate with Ministry of Land, Water and Environment at the time of preparing inventories.

Refrigeration Technicians: Refrigeration technicians are the main users of ozone depleting substances (ODSs) in their work area. As a result, these people need the know-how with regard to safety recovery of ODSs. They are assisted by the Department Of Environment on ozone unit.

12.2 International Level Institutions
United Nations Industrial Development Program (UNIDP)
This organization gives investment components and equipment to the Ministry of Land, Water and Environment. This aids the Ministry in ozone mitigation processes.

12.3 United Nations Environmental Program (UNEP)
The United Nations Environment Programme (UNEP) coordinates United Nations environmental activities. It assists Ministry of Land, Water and Environment in implementing environmental policies and practices. UNEP has financial aid and training courses in the development of guidelines and treaties on issues related to ozone mitigation (UNEP, Vol.1, refrigerants 2001).

12.4 National polices
The national policy and legislatives on ozone depleting substances is pointed out by the Ministry of Land, Water and Environment. The law stated- Regulation for the issuance of permit for the importation or exportation of ODS and ODS- based equipment or products (legal notice No. 117/2010): The objectives of the legal notice are to:

- Control and limit the ODS, imported to Eritrea.
- Ensure that ODS are imported through formal import permits.
- Promote the use of ozone friendly substances, products, equipment and technology.
- Phase out the use or consumption of ODS and products. Articles in this notice include scope of application, restrictions, permits, powers of the Ministry of Land, Water and Environment, obligation of importers and exporters and list of controlled ODS and their mixtures.

13. Eritrea's Mitigation Measures and Implementation Strategies

13.1 Eritrea for confirmation of Convention and Protocol
Eritrea ratified the Vienna Convention and the Montreal Protocol on of March 2, 2005 with all four amendments in 27th June the same year. However, Eritrea had already realized the problems associated with Depleting Substances (ODSs) on Human health and other life, well before it ratifies the convention. As first step to address the concern, Eritrea through the Department of Environment of the Ministry of Land, Water and Environment has undertaken nationwide inventory of ODSs and ODSs based equipment in 2002.

Although Eritrea produces and consumes minor amount of any of the substances controlled by the Montreal Protocol, it is very vulnerable to the effect of ozone layer depletion and climate impacts (Some ODSs are also greenhouse gases). Eritrea's consumption is mainly on refrigeration and air conditioning.

13.2 Eritrea's mitigation and implementation to lessen ODSs
Since the ratification of the Montreal Protocol on Substances that Deplete the Ozone Layer, Eritrea has accomplished several tasks to ensure effective implementation of the Convention and Protocol. These tasks include the following activities:

13.3 Establishment of the Ozone Unit office to facilitate the works
Establishing the Ozone unit under the responsibility of the Department of Environment is the first crucial step. This makes the work for better identifying the ODS and ODS containing equipment with the help of Refrigerant Identifier tool. The Department of Environment operates without any cost. The aim for making free charge is for the sake of public encouragement ((Kebrom Asmelash (head officer of ozone unit), 2nd May, 2016.

13.4 Declaration of legal notice for the issuance of licensing system for the importation and exportation of ODS and ODS based equipment
The Eritrean government lay-out the gazette which has been published on 23rd August 2010 under declaration article 177/2010. The gazette was printed under the volume number 18/2010. The gazette has certain rules and regulations on the exportation, especially in importation of OD and ODS containing equipment.

13.5 Phased-out all CFCs and Halons
Eritrea, as part of the Montreal Protocol has phased out Halons and CFCs in 2007 and 2010 respectively. As is shown in the given table and chart; Eritrea as a small nation did phase-out these ODSs containing chemical elements at the required time.

Tab. 2: Phased-out all CFCs and Halons.

Year	Substance
2010	CFC-12
2010	CFC-11
2010	CFC-113
2010	CFC-115
2007	Halons

Source: Ministry of Land Water and Environment, Department of Environment.

Tab. 2 shows the total phase out of both Halons and Chlorofluorocarbons (CFCs). The phase out schedule was given by the Montreal Protocol to each party. So every party should have follow the schedule for phase out the highly ODS at the required time. The need to phase out these chemical elements is due to their highly Ozone Depleting potentials (ODP). Eritrea did phase out in 2010 CFCs chemical elements like CFC-12, CFC-11, CFC-113, CFC-115 and Halons in 2007. Even though these chemical elements are phased out, it does mean that they are totally eradicated because some equipment works with the support of CFC and Halons. But the production and consumption is much lesser nowadays.

13.6 ODS and ODS-based Equipment Survey (HCFC 2005-2010)
Being the member of the Montreal Protocol Eritrea has taken responsibilities of controlling, surveying these ODS and ODS based equipment. As the above table 2 shows the CFC and Halons has been phase-out in 2010. Seeking an alternative is the main concern. Hydro chlorofluorocarbons (HCFCs) came in to existence as an alternative. The given table 3 shows that the annual HCFC-22 Consumption in 2010 was high (20,31 tones) as HCFC is an alternative for CFC. Later on, in 2011 a fall in consumption is shown and in the coming year in 2012 it raised-up again due to emergence of some equipment supported with HCFC. Finally a fall is seen in 2013 and 2014 by 18,3 and 18,1 respectively. Even though the consumption of HCFC has been changing since the year 2011, the mitigation strategies of Eritrea adopted some measures for complete phasing-out the HCFC and replace by HFC by 2040.

Tab. 3: Annual HCFC-22 consumption in tones.

Year	Annual HCFC-22 Consumption in tones
2010	20,31
2011	17,5
2012	18,6
2013	18,3
2014	18,1

Source: Ministry of Land Water and Environment, Department of Environment.

Training to about 150 National Refrigeration and Air-Conditioning technicians (RAC)
This training comprises of Private and Public sectors. Out of the RAC-technicians, 24 are certified with European Standard Certification system. These would enable Eritrea to effectively address the issue of safe and legal work of refrigeration systems (Tesfalem, Hagos, Kahesai, Mogos and Halisslassie, April, 2015). Importantly this will enhance capacity towards ensuring efficient and timely implementation of the Phase out of HCFCs at scheduled time and replacement by alternative HFCs.

13.7 Establishment of Refrigeration and Air Condition Training Centres
The Department of Environment in collaboration with the United Nations Industrial Development Organization (UNIDO) and United Nations Environmental Program (UNEP) decided to establish two regional refrigeration training centres (UNEP, Vol.6 Methyl bromide) with the objectives stated as follows:

- To provide service of recovery to refrigeration technicians
- To provide training to newly recruited/ licensed technicians so as to make them certified in the refrigeration practices, and
- To introduce students with new available technologies and train them in good refrigeration practices.

13.8 Distributed several Refrigeration and Air-conditioning equipment to Private and Public institutions
This will assist technicians and refrigeration sectors perform safer maintenance for effective recovery of ODS and ultimately eliminates the release into the air. Accordingly, tools and equipment for the two training centres were acquired and delivered to the Department of Environment of the Ministry of Land, Water and Environment.

The Department of Environment has already established two training centres at:

- College of Marine Science and Technology in the Port City of Massawa.
- At the Ministry of Energy and Mines, Renewable Energy Centre at Asmara.

14. Findings and Analysis of the Study

All the activities carried out by Ministry of Land, Water and Environment (MoLWE) has been described above. Eritrean policies and adoptive measures to mitigate ozone depletion are further analyzed in this study. The results found from the policies of Eritrea for regulating of importation of ozone depleting substances (ODSs) are implemented in the ground. Offering training courses to 150 refrigerant technicians throughout the country was a helpful platform to conserve ozone depleting substances (ODSs) from being discharge to the atmosphere. The first method includes, transferring the refrigeration gases to a small cylinder (temporal container). Once the refrigeration takes its services, the previously taken-out gases should be returned for

reuse. This whole process is called gas recovery process and is carried out by a device named gas recovery machine. In this gas recovery system, refrigeration is fully safe from out flow of ozone depleting substances (ODSs) like HCFCs -R22 to atmosphere. This means there is no out flow of gas to atmosphere.

In this research the survey done consisting of interviews and discussions to investigate how much the given training courses has been traced and followed in the ground. We have managed to choose interview survey techniques in order to acquire the necessary data through intimate interviews with the refrigerant technicians.

In this survey, five refrigeration and air conditioning technicians' shops have been taken into consideration to find out the efficient use of the recovery gas machine. According to the survey only one refrigeration and air conditioning technicians shop follows all the necessary steps in the gas recovery system. Thus, technicians who have not followed the proper recovery machine have given the following reasons:

- The processing of transferring gases into a temporal cylinder then replacing it, is time consuming process, and
- Some of them do not have the recovery machine.

Among the five selected refrigeration technicians shops, only one shop is following the necessarily techniques certified by Ministry of Land, Water and Environment. This is known by Hagos Keleta refrigeration and air conditioning repair and sales work shop located along Tegadelti Street near Freselam junior school. One of the technicians who is responsible to run the shop is Tesfalem. He is a highly skilled and possesses a good English language skill. From this observation, the rest of four shops do not acquire the same level of education and skills. This is a reason why we have found only one shop that follow up and utilize the recovery gas machine properly, carefully and neatly.

15. Conclusion

Ozone layer protects the earth surface from harmful ultraviolet radiations. It is formed by composition of three oxygen atoms. This layer is found in the stratosphere which is far from the earth's surface about 10-50 km. Moreover, this layer has a thickness of 10-20 km. Ozone molecule has a reaction of dynamic equilibrium character, meaning the number of ozone molecules breaking down are equal to that of being created. The use of this stratospheric layer is to filters out the harmful ultraviolet radiation (UVB). As a result, it has a great significance in protecting life on earth. However if ozone layer is damaged by anthropogenic activities the harmful radiation began to descent toward troposphere. In return, a great deal of damages has been experienced up on the environment and human health. Most of the time, the effect of falling ultraviolet radiation (UVB) felt across high latitudes than in low latitudes. Because of the polar stratospheric clouds that catalysis the chemical reactions over high latitudes and the movement and concentration of ozone depleting substances (ODSs) from the entire world toward cold regions.

Generally speaking, the effect of ultraviolet radiation (UVB) is not much felt in Eritrea. This is due to its location within tropics. Saving ozone layer from depletion is not the mission of few, but it needs a collective activity among countries, that ratify Montreal and Vienna Conventions. Eritrea has adopted several polices and measures to mitigate ozone layer since 2005. Established ozone unit office as well as ratifies the legal notice for issuance of licensing system for the importation of ODS and ODS based equipment.

The role further being played by Eritrea through Ministry Of Land, Water and Environment also include, offering training of custom officers and refrigeration Technicians. The training mainly covers the technical aspect of recovering Ozone depleted substances (ODSs) from air conditioning and refrigeration. However, the findings and discussions of the study shows that only one shop follows proper gas recover out of five refrigeration technician shops (RTS). Therefore, it is concluded that only few technicians uses and follows the measures that formulated by Ministry of Land, Water and Environment and the others are not able to follow the measures given by the Ministry of Land, Water and Environment because of some problems stated above.

16. Recommendations

This research paper finally concludes the work with the following recommendations that may help in mitigating ozone processes in Eritrea.

1. The Ministry of Land, Water and Environment should give to refrigeration technicians, a continuous training on gas recovery processing and increasing their understanding on environmental awareness.
2. The Ministry of Land, Water and Environment should solve the problem of lack of recovery machines to all repairing refrigeration workshops.
3. Ministry of Land, Water and Environment, Department of Environment in particular, should provide the disposal area for the previously used impure ozone depleting substances (ODSs), specially CFCs and HCFCs gases.
4. And it is also recommended to Refrigeration technicians to use the recovery machines as well as its necessary steps in processing.

References

Albritton, D. 1998: What Should Be Done in a Science Assessment In Protecting the Ozone Layer: Lessons, Models, and Prospects.

Allied Signal Corporation. “Remarks,” International CFC and Halon Alternatives Conference. Washington, DC. 1989.

Alternative Fluorocarbons Environmental Acceptability Study (AFEAS), Washington, DC, 1995.

Andelin, D., John, V. 1988: Analysis of the Montreal Protocol, Staff report, U.S. Congress, Office of Technology Assessment, Jan. 13, 1988.

Angell, J. K., Korshover, J. 2005: Quasi-biennial and Long-term Fluctuations in Total Ozone, Monthly Weather Review vol. 101, pp.426–43.

Anderson, J. G. 2008: The Measurement of Trace Reactive Species in the Stratosphere: An Overview. In Causes and Effects of Stratospheric Ozone Depletion: An Update, Washington, DC: National Academy Press.

Stedman, D. H. 1981: Atomic Chlorine and the Chlorine Monoxide Radical in the Stratosphere: Three in Situ Observations. Science, vol.198.

Interviews with refrigeration technicians: Tesfalem, Hagos, Kahesai, Mogos and Halisslassie, April 2015.

Open interviews with Mr. Kebrom Asmelash (head officer of ozone unit), 2nd May, 2016.

Stephen, O., Morehouse, E. T. Jr., Miller, A. 1994: The Military’s Role in Protection of the Ozone Layer. Environmental Science and Technology, vol 28, no. 13.

United Nations Environment Programme (UNEP): strategies and policies for the implementation of the Montreal protocol in Norway. In: Environmental Management in developed countries, pp. 19-22, 1997.

United Nations Environment Programme (UNEP): Protecting the Ozone layer Vol.1 refrigerants 2001.
United Nations Environment Programme (UNEP): Protecting the Ozone layer Vol.6 Methyl bromide.

DEPLETING STATE OF STRATOSPHERIC OZONE: A CHALLENGING CONSERVATION FOR GLOBAL COMMUNITY WITH SPECIAL REFERNCE TO ERITREA

Summary

No doubt, the ozone layer acts as a shield against the harmful ultraviolet radiation on earth. The absorption of ultraviolet radiation in the upper stratosphere prevents potentially lethal levels of ultraviolet rays from reaching the earth's surface. The formation and destruction of ozone led to the absorption of ultraviolet rays. In the absence of this shield, life could not exist on earth.

Depletion of ozone layer is today's major environmental concern. A group of chemicals, known as CFCs (chlorofluorocarbons) is the main culprit for thinning out the ozone layer. These CFCs were widely used for decades as fluids in air conditioners and refrigerators, propellants in aerosol sprays, and blowing agents for foam insulation and cosmetic goods. CFCs emissions are also produced by supersonic jet aero planes, nuclear explosions and volcanic dust erupted from the earth's surface. Possessing strong oxidizing power, ozone is usually used in medicine, as a disinfectant for drinking water and beverages. It is also very effective as a reagent in purifying industrial effluents and treating contaminated river water. In ship cabins, underground mines and tunnels where sunshine is absent all the year round, ozone is often utilized for purifying the air. It kills organic matter without producing disgusting dump stinks.

Within the troposphere, CFCs are chemically non-reactive, but in the stratosphere it is highly reactive as the intense ultraviolet radiation breaks them down and liberates chlorine atoms. Chlorine acts as a catalyst (A catalyst accelerates a chemical reaction without itself being altered by that reaction) in chemical reactions that convert ozone to oxygen. In this way, each chlorine atom can destroy tens of thousands of ozone molecules.

Increased propagation and overexposure of ultraviolet rays may cause not only serious human health problems but it will affect the other mammals too. Its harmful effects may include a greater risk of skin cancer in human and animals, eye damage including cataracts, immune deficiencies, and reduction of crop yields and destruction of certain forms of aquatic life. Higher dosage of ultraviolet rays lead to reproductive failure also particularly in birds and lizards and hence threaten the ecosystem. According to an estimate, every 1 per cent decline in stratospheric ozone concentration translates into a 2 per cent increase in the intensity of biologically active ultraviolet rays that passes through the ozone layer. The actual amount that reaches the earth's surface hinges on cloudiness and air quality. Various studies suggest that a 2.5 per cent thinning of the ozone layer could boost the incidence of human skin cancer by 10 per cent. As whole, reaching of ultraviolet rays on earth is hazardous. It is mainly caused due to overexposure to the ultraviolet radiation i.e., UVB. What measures could be adopted to protect ourselves from this dangerous radiation?

As we know that our body has natural self-defensive mechanism to protect against any kind of attack and so is the case with the ultraviolet radiation. Besides, we must adopt some strategy which can provide adequate protection. We should avoid such places where UVB is maximum. Such places include Sea beaches because sand reflects up 50 per cent of the incident UVB. In the same way water transmits UVB to a depth of a meter or so, and a wet T-shirt allows 20 per cent to 30 per cent of incident

UVB to reach the skin. The beach is not the only place where a person is likely to be exposed to high levels of UVB. Skiing at high mountain elevations, where UVB is more intense than at Sea level, results in significant exposure. In addition, snow is even more reflective of UVB than the beach sand. As whole two remedial measures can be adopted to protect against UVB. First of all we should avoid the sun at its greatest intensity, which is between 10 A.M to 3 P.M. Secondly, we should apply a 'Sunscreen' on most commonly exposed surfaces such as the forearms, face, neck and wearing protective clothing is a wise strategy. Experts have recommended a broad spectrum Sunscreen that provides protection from both UVB and UVA. In the Sunscreen we should see the degree of protection offered i.e., Sun protection factor (SPF). Higher the SPF value, the longer the protection lasts. Experts recommended a minimum SPF of 15.