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Sustainable Environmental Economics by Air Pollution Prevention and Control Approach

Rasoul Yarahmadi[1*] , Somayeh Soleymani-Alyar[2]

1. Professor, Department of Occupational Safety and Health, occupational health research centre, Iran University Medical Science (IUMS), Tehran, Iran. (Corresponding Author) Email: Yarahmadi.r@iums.ac.ir

2. MSc student, Department of Occupational Safety and Health, Iran University Medical Science (IUMS), Tehran, Iran.

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ABSTRACT

Air pollution as a principle challenge of today international societies is at the centre of attentions. In particular, Direct and indirect effects of air pollution on various aspects of human life, health and welfare being, and its surrounded environment causes to Countries and authorities in worldwide seek for suitable methods of engineering and management to solve it. In this study, we will show the necessity and importance of pollution prevention from sustainable environmental economics aspect. Where, Modern technologies are increasing daily to control pollutants emitted by stationary and mobile sources, the key role of economy as an important element in apply of various solutions, technologies and more important, in decision making process is being highlighted. As, most of the new technologies in spite of high efficiency are facing some problem in application just because of cost issues. Human health and welfare is depended on its surrounding environment. Labour force of a society and so, its productivity, is a key development index of that society. It has been found from studies that worker productivity is affected by air pollution, even at lower concentration of threshold values. By considering pollution prevention 1990 act, and meeting it, not only the pollution will be decreased, but also, it will assist to keep natural resources as a sustainable capital and so, maintaining of health ecosystem (health society is a part of health ecosystem). As some companies by attention to the air pollution considerations in design and material substitution could achieve much benefits.

KEYWORDS: Air pollution, Pollution prevention, air quality, emissions, environmental economics

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1. INTRODUCTION

Air pollution from combustion and industrial gases is growing daily and causes environmental problems. Industry and energy generation sectors poses most contribution of world carbon dioxide emissions, as designated 60% of total carbon dioxide emission to them. Emissions in these segments are due to boilers and burning furnaces of fossil fuels and generally are emitted from high stacks of gas exhaust (R. Yarahmadi, Soleymani- Alyar, Somayeh, 2015). Air pollution is a definite environmental problem as well as one of the main challenges, modern societies are facing it. Air pollution is responsible for most harmful effects on human health, animal living, natural ecosystem and man-made environment. It is also, main climate change element due to increasing greenhouse effect, acidic rain and ozone layer depletion which forms main world environment concern (Dimitriou & Christidou, 2011). Air pollution is a main health problem that affects millions people in the world. In support if this fact, world health organization has estimated that 2.4 million people die yearly, just because of air pollution effects. It was known that apply of pollution reduction strategies could have substantial health profits (SIERRA-VARGAS & Teran, 2012).

Air pollution occurs as indoor and outdoor. It causes by human and nature activities (Dimitriou & Christidou, 2011). Air pollution effects are direct and indirect. Its direct effects include, health, damage to materials, ecosystem, and poor visual. Low direct effects are acidic rain due to released chemicals to atmosphere. Changes in human behaviour is also results from air pollution, like; habitants of urban areas with high pollution are relocate, or tourists stay far from of pollutant cities. Most indirect effect of air pollution is climate change. Biomass fuels and fossil cause air pollution, as well as warming of earth atmosphere which is due to release of greenhouse gases (Hutton, 2011). Various air pollutants of indoor and outdoor affect human health and have critical harms to all the people in worldwide such as, breathing or cardiovascular disorders, asthma, lung cancer which can be fatal. It is known that everybody breathes 14 litter air daily. So, it is clear that air pollutants impose main hazards to human health. According to world health organization (WHO, 2006, 2009) more than 2 million early death can be attributed to air pollution of urban indoor and outdoor (Dimitriou & Christidou, 2011). A mass analysis of carbon monoxide emissions as a function of vehicle age declared that cars and trucks with more than ten years life are responsible for 58% of constant CO emission from exhausts of all cars and trucks (Singer & Harley, 1996).

2. THEORETICAL & EXPERIMENTAL FRAMEWORK

2.1. Environmental economy and sustainable development approach

Each economic system is a part of social system, which is a part of natural system. Consequently, human health and welfare could not be separately from ecosystem health. Human health begins and end with its surrounded ecosystem health. Actually, Care of ecosystem health is care of our health and therefor, prevention of highly health risks and medical compensates (William Franek, July 2003). It is a fact, if we continue to deny difference between income and capital for nature, wrongly we will destroy nature as an income item. So, we will reach a place that adverse effects of damage to nature will be irreparable and so we cause destruction of our planet and probably extinguish ourselves.

To terminate all of these, during half of the last decade, developed countries begin to reverse health effects and reduce costs of environment pollution in cities. For this reason, environmental economy -as a subfield of economy- established to attended environmental subjects by using neoclassical economic standard methods, as well as, taking responsibility of theoretical and experimental studies to survey economic effects of local and national environmental policies around world. As a result, subjects as costs and pollution profits, corrective environmental policies to inquiry air pollution, water quality, toxic substances, solid waste, and global warming are very important issues to analysts in propose of solutions.

Over the last 50 year, health effects of environmental pollution, especially air pollution has become in central attention of most epidemiological studies for risk assessment issues and environmental economics. By increasing society awareness from human health concerns and air quality, a large body of

epidemiological research has been formed, showing adverse health effects of air pollution and concentrate on harmful effects of air pollutants on public health. Based on research finding, which confirming that air pollution causes different levels of risk to human health and environment, Authorities of environmental laws in most countries were applied strict air quality measures. These investigations also, declared that human health through these exposures probably be affected more than believed before (WHO, 1999). At the present, evidence showing the relation of long term exposure by low concentrations of Particulate Matter in air with the rate of death and other chronic effects such as, increased rates of bronchitis and reduced lung function (Gurjar, Molina, & Ojha, 2010).

A basic principle in microeconomic states that, if production be allocated as efficiently, marginal costs should be equalized among manufactures. About environmental laws, same principle should be applied. Produced goods are improved at environmental quality (Fowlie, Knittel, & Wolfram, 2012). Most pollutants are emitted by several sources in different economic sectors. For instance, any high temperature combustion process releases nitric oxides (NOx), therefore, airplanes, trains, ships, trucks, cars and stationary sources such as, power plants are sources of NOx emissions. Recently, all of them are considered for different NOx emission standards in United States. Generally, health and environmental damages by a given amount of specific pollutant in a known place at the specified point of time despite of its source are same. Therefore, Cost effective laws of NOx emissions should be equal to Marginal Cost of remediation among sources same at those dimensions (Fowlie et al., 2012).

2.1.1. Air pollution effect on worker productivity

In study was done by Zivin and Neidell, it has been shown that how the air pollution can influence on agriculture's worker productivity. As their productivity is decreased more than the people are working indoor workplaces. In this study, ozone pollutant effect on worker productivity has been investigated. It has been found that a change of 10 ppb in mean ozone exposure result in main change and increase of 4.2 % in agricultural worker productivity. The most important finding of study was that ozone had significant adverse effect on worker productivity even in lower levels of air quality standards of most world, suggesting that strict laws about ozone pollution will offer more additional benefits (Zivin & Neidell, 2011).

In another study was done by Lichter, et al. about pollution effect of particulate on productivity of soccer players in outdoors, they found productivity reduction due to particulates. It was notable that negative pollution effects had been observed even in lower concentrations of EU established levels. Results of study which, were done by measuring particulate matter concentrations, confirmed negative effect of these substances on productivity. This negative effect was considerable, when it was apply to nonlinear relation of dose- response. In particulate concentrations more than EU legislated threshold, 50 micrograms per cubic meter, the productivity decreases significantly. The authors at the end of their paper also suggested more research on large groups of worker representatives in the case of pollution effect on physical and cognitive productivity should be done. Thus, they can improve and expand our knowledge toward benefits of environmental laws (Lichter, Pestel, & Sommer, 2015).

2.2. Emissions from mobile and stationary sources

Combination of rapid industrial development (particularly in petrochemical and heavy industries), strong economic grow and urban expanding result in large increase of pollution emission ((J.I.C.A), March 2004)[1].

The emissions of artificial sources are through stationary and mobile sources. Stationary sources are areal. Mobile sources also classified as on-road vehicles and non- road vehicles (R. Yarahmadi, Soleymani-Alyar, Somayeh, 2015). Based on comparison has been done by natural resource agency on emissions from mobile and stationary sources, it has been found that emissions of on-road mobile sources is more

[1] Japan International Cooperation Agency

than 12 times higher than emissions from stationary sources. Also, in comparison of this agency, for collected payments from stationary and mobile sources, it is determined that collected fee of motor vehicle per pollution pound was approximately 11 times lower than assessment fees for stationary sources (Legislature).

2.2.1. Carbon dioxide emissions

CO2 emissions result from number of sources. In industry and energy generation sector, most sources have huge emission volume that make these sources function of adding CO2 capturing technology. Large number of small point sources and in the case of transportation, mobile sources that are determined from other parts, make it less practical to capture them at present time. However, Technology changes in production and nature of transportation fuels may be make it possible to capture CO2 from the energy used in this section.

Technological changes like, central production of fluid or gasified energy carriers (e.g, methanol, ethanol, hydrogen) from fossil resources or centralized generation of these energy carriers or electricity from biomass may be allow CO2 capturing and storage. These stacks could explore as huge stationary sources, to distinguish of them from mobile sources such as sources of transportation sector and from small stationary sources such as small heating boilers used in residential segment.

Recently, coal is a predominant fuel of power plant. Fuel selection in industrial unit is sector-specific. In chemical and purge sectors, oil and gas are primary fuels. In order to decrease CO2 emissions from power plants and industry by using of CO2 capturing and storage, it is vital to know the origin of emissions and its geographical relation by considering potential storage chances (Coninck, Loos, Metz, Davidson, & Meyer, 2005).

There are three major methods to reduce CO2 emission associated with energy generation without decreasing economic output:

- Improvement of efficiency in energy conversion and end-use process
- Change to fuels with lower carbon contain (non-carbonic resource, such as renewable energy and nuclear energy)
- Separation of released carbon in energy generation (R. Yarahmadi, Soleymani- Alyar, Somayeh, 2015).

3. STRATEGIES TO AIR POLLUTION MANAGEMENT

"The ability to control air pollution in a coordinated manner is known as Air Pollution Management". Strategies of Air pollution management could occur in different form as, cost benefit analysis, air quality standards, emission standards and economic motives (William Franek, July 2003). The goals of each strategy is given briefly in table 1.

Table 1. Different common strategies of air pollution management

Strategies of Air pollution management			
air quality standards	economic motives	emission standards	cost benefit analysis
This strategy establishes ambient air quality standards from dose-response and other toxicology data. It sets a pollutant exposure value, below threshold values, so that there can be no	The economic incentive strategy relies on an emissions tax to motivate polluters for installation of effective air pollution control devices (William	Emissions Standards establish an approved range of emissions for a point or area source to meet local, regional and or national targets of that area (William Franek, July 2003).	The goal of this strategy is to select the pollution control alternative which best minimizes the effect of air pollution damage in the most cost effective manner (William Franek, July

result in air pollution damage. When an ambient air quality standard is established, then, regulatory authorities are responsible for creating and implementing a plan that will ensure, the air quality standard is not exceeded (William Franek, July 2003).	Franek, July 2003).		2003).

3.1. Air quality management in air pollution control

Environment quality definitely is a global concern. Air pollution has no boundaries and its reduction poses high importance. Countries now, legislate environmental law that should be meet by mobile and stationary sources (Heck, Farrauto, & Gulati, 2012). Air quality management targets the protection of environmental quality by characterizing degree of pollution tolerable, allowing it to local authorities and polluters for devices and applying measures to ensure that this pollution degree will not be exceeded. Usual practices in air quality management are control measures in source, for example, requirement of using catalytic convertors in vehicles or using emission standards in burning furnaces, land-use planning, and factories closing or traffic reduction during adverse climate. The best air quality management emphasizes on keeping air pollution emissions in minimum (Stellman, 1998). We will state some strategies and policies related to emission reduction from stationary sources in following:

- Encourage: by using of materials and methods minimizes air pollution
- Support: by the use of developed standards, the use of fuel efficient heating equipment, and other appliances, like, cooking equipment, refrigerators, furnaces, boiler units, and low or zero-emitting architectural coatings. Provide incentives to encourage the use of clean air technology.
- Encourage pollution prevention and source emission reduction strategies through:
    - Process change
    - Best management practices
    - Preventive inspection and maintenance programs
    - emergency response planning
- Considering legislation support which improves clean industrial technologies, and more efficient stationary source combustion equipment and energy generation (SCAQMD)[1].

As mentioned above, one of the relevant strategies on emission reduction from stationary sources is pollution prevention. We will pay more it in following.

4. AIR POLLUTION PREVENTION

Air pollution prevention is defined as pollutant reduction at sources. This is a promise way to environmental protection and various activities such as, using products including low pollution during manufacture, apply or disposal. Pollution also, can be prevented by steps of reduction in energy consumption or release restriction of induced pollutant over manufacturing process. Hierarchy of pollution control which approved at pollution prevention1990 act, placed pollution prevention at the top

[1] "SCAQMD" is the air pollution control agency for all of Orange County and the urban portions of Los Angeles, Reverside and San Bernardino countries, among the smoggiest regions of the U.S.

of list. In spite of main prevention attaches in pollution control, up to now, main focuses for developed technology is remediation after pollution rather prevention (Mehndiratta, Jain, Srivastava, & Gupta, 2013). Pollution prevention act (1990) completely changed the attentions from measurement and control of industrial emissions to prevention of pollution generation (William Franek, July 2003).
According to definition of nature, pollution prevention is begin before pollution induction. Therefore, it depends on considerable foresights and planning. In this state, pollution prevention is more effective than common control strategies. About air quality, general strategy for pollution prevention is reduction of air pollution amount. This goal is accomplished best by using a suitable hierarchy. While each step in pollution prevention process is an essential action of pollution prevention, their priority and sequence is important. Effective Pollution prevention steps are as following; Source reduction, Recycling, Waste Treatment, disposal (William Franek, July 2003). As mentioned, pollution prevention emphasizes on reduction or elimination of waste production before entry of their emission into environment. Apply of pollution prevention strategies does not ensure that all the wastes of production process will be eliminated, but these strategies has been designed to equip industry with cost- effective tools in order to repel with unnecessary pollution and waste generation by each process phase (William Franek, July 2003). Pollution prevention refers to "sources reduction" and other operations uses raw materials, energy, water or other sources to reduce or eliminate waste generation. This strategy also include using of reagents with low toxicity, renewable and processing materials where it is possible and produce of more environment friendly products (Chirag, 2015). In figure 1, this hierarchy is shown (William Franek, July 2003).

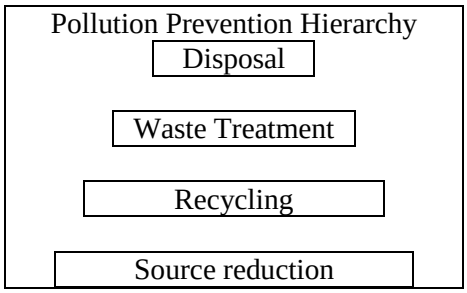

Figure 1. Hierarchy of pollution prevention (Theodore, Louis and McGuinn, Young C., 1992, Pollution Prevention, Van Nostrand Reinhold: New York, p.107)

4. 1. Life Cycle Assessment (LCA)

Life Cycle Assessment is a decision making tool as well as management that provides information about environmental effects of products and various process in order to assess essential corrective measures to make the entire process efficiently by optimum applying of resources and minimum waste generation (M.O.E.F)[1].
This assessment actually, is a systematic approach linking product Life Cycle, from design to disposal step, with environmental effects induced in each step. But, primary objection of LCA is complexity of problem in determining of all product related effects during its life cycle (Matthews, 1999). It is notable that LCA is along pollution prevention.

5. Contribution of Economy in Applying of New Air Pollution Reduction Technologies

New technologies of pollution reduction such as, Non-thermal plasma techniques, Nano catalysts, ceramics and membranes are more known of modern methods. Some of these techniques has been used

[1] Ministry Of Environment, Forest and climate change

with approach of pollution prevention and some others to pollution control and in some cases both of them. As well as they had good economic justifications while some examples of modern technologies such as Nanofabrication and membranes despite of high efficiency, because of expensive costs face problems in usage.

5.1. Nanocatalyst as a modern technique in air pollution reduction

Air pollution could be reduced by using of nanotechnology in various ways. One of the most common methods is using Nanocatalysts with increased surface area for gas reactions (Bhawana & Fulekar, 2012; Chirag, 2015). Nanotechnology has been developed to achieve and maintain the sustainable environment target. Nanotechnology could play an important role in pollution prevention. According to recent study, United States in one of estimation saved 100 billion dollar in one year by using of domestic lighting based on nanotechnology. Total amount of energy consumption decreased approximately 10 percent and carbon emissions has been decreased 200 million ton in year (Mehndiratta et al., 2013). This technology offers new treatment approaches which are most effective in pollution reduction levels and are very cost-effective in comparison with the other available techniques (Chirag, 2015). Exhaust containing volatile organic compounds (VOCs), carbon monoxide, nitric oxides (NOx), ozone can be convert to less harmful non pollutants in reasonable temperatures and cost-effective systems by using of heterogeneous catalysts. Appling proper catalyst system convert pollutants to non-pollutants in low energy requirements and high conversion rates, result in cost- effective pollution control. Application of catalytic systems for pollution remediation was not exist before 1976, but now this technology is a world multibillion dollar business that targets gasoline automobiles and diesel fuel and trucks, destruction of VOCs from stationary sources such as industrial units of chemical processing, nitric oxide reduction from industrial power plants and stationary motors, ozone decomposition in commercial high-flying planes, pollution from small motors and etc. catalysts used for applications of future pollution reduction is increasing at a high speed of next decade (Heck et al., 2012).

Nanofabrication methods are following to achieve an effective control over shape, size, and situation of Nanometre metals. Catalyst Types, which are used in automobiles, contain Platinum Group Metal (PGM). Researchers have suggested an automobile catalyst made of Nanofabrication result in high decrease of PGM load level and cause to sustainable source usage. (Mehndiratta et al., 2013). Nanofabrication poses large potential of effective pollution control, but recently, it faces more problems particularly because of its high cost, which impeded it being commercial (Bhawana & Fulekar, 2012).

5. 2. Membranes in air pollution control

Membranes are using widely to gas segregate, especially for CO2 capturing, post combustion, and oxyfuel combustion. Depending on application, hydrogen sequestration or CO2 from flue gases with high efficiency is achievable. Main disadvantage of membranes for being attractive option is their high cost (Nassos, 2007).

5. 3. Non-thermal plasma

Plasma methods to environment pollution reduction have been investigated for more than 20 years and shown to be effective especially in remove of small concentrations of wide range pollutants in waste gas streams, generally lower than 1000 ppm (Whitehead, 2010). The technical application of plasma is growing due to its unique characteristics and technological nature (R. Yarahmadi & Moridi, 2012). Major advantages of NTP technologies are; performance under ambient conditions, mean capital investment, compact system, simple operations and short reaction time (Raju, Reddy, Karuppiah, Reddy, & Subrahmanyam, 2013).

6. CONCLUSION

Air pollution due to human activities is growing and causes adverse effects on environment, health and welfare of man life, properties and other creatures. In addition to the Air pollution influence on environmental economics due to pollution, as it has adverse effect on worker's productivity, one of the main countries capitals and also principle elements of countries development, it is understandable that it is play a key role in sustainable development of societies. If we were in this belief that costs we pay for our health care and welfare, could be invested for our surrounded environment, in this attitude we will move in environmental sustainable development. Therefore, natural resources will be man's essential capital not as an income source. Policies made for pollution control and it's reduction on both stationary and mobile sources are along air pollution control, while if they were in pollution prevention 1990 act, so that, it will result in pollution reduction, conservation of raw materials and natural resources and finally, sustainable natural ecosystem which health society and thus human healthy life and welfare will be achievable.
The role of new technologies in mitigation and pollution control is not negligible. Especially, it is more important when apply with the aim of pollution prevention. But because of some problems in this way, awareness and economic justification of these technologies in particular for stakeholders are significant elements that should be considered in policies.

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ETHICAL CONSIDERATION

Authenticity of the texts, honesty and fidelity has been observed.

CONFLICT OF INTEREST

Author/s confirmed no conflict of interest.