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Effect of environmental pollution on animal and human health: A review

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ABSTRACT

Rapid industrialization and development of modern technology are amongst the foremost factors to blame for the general pollution. Livestock sector is one of the several industries that have faced criticism because of its influence on the environment. There is particular concern about the pollution caused by effluents, gases, heavy metals, industrial contaminants and particulate emissions which significantly affect health of both livestock and man. Reciprocally, pollutants from livestock system can affect atmosphere, water and the food chain. However, with rapid population growth there is phenomenal increase in the demand for livestock products, this situation has led to change in the farming system from subsistence farming to commercial and from pastoral livestock systems to more intensive systems of production. Thus, there is a need to address these problems at various levels. The present review has been undertaken to determine the impact of different elements in the environment that cause pollution in animals and human beings as well as pollutants emanating from the intensive livestock production systems and adequate strategies to overcome this problem.

Key words: Animal health, Chemical pollutants, Environmental pollutants, Gases, Particulate matter

Environment is a complex natural resource system that has originated from millenniums of evolutionary processes (Patra and Swarup 2000). History of environmental pollution dates back to ancient times when an Eskimo woman died some 1600 years back with autopsy lesions comparable to that of black lung disease as observed in the coal mines (Bell *et al.* 1990). However, with rapid mechanization and industrialization, the amplitude of pollution has increased many folds especially during the 21st century (Choudhary and Naha 2002). While, environmental pollution confined only to human health hazard at one time, today, the effects of pollution are considered far extensive, affecting various units of the biosphere (Powers 2003). Pollution from livestock system includes effluents, wastes, gases and odors, contamination of animal feed, air borne particulates and radioactive materials. Reciprocally, Singh and Pandey (2005) reported water pollution threats in areas with high livestock density through spreading of manure. With ever expanding population, there is always a potential for environmental pollution with its adverse consequences both in humans and animals. Therefore, greater importance needs to be emphasized in solving multidisciplinary problems. With that in mind, the animal scientist can contribute greatly to issues spanning animal production and the environment. In this review an attempt has been made to discuss some of the effects of pollution on livestock and human health as well as the environmental influences of pollutants emanating from animal production systems along with the task of animal scientists in solving issues relating to environment.

Particulate matter: The particulate matter often referred to as dust, is a complex mixture of suspended particles having varying composition, size, shape and density (Kotwal *et al.* 2005). In intensive housing system, the particulates mainly comprise manure, hair and skin cells, spores, molds, pollens, insect parts, mineral ash, feathers, endotoxins and feed dust (Schiffman *et al.* 2000). About 80 to 90% of particles originate from feed, 55 to 68% from litter, 12% from animal's surfaces, nearly eight percent from fecal material and to a lesser extent from friction against floors, walls and other structures in the animal house (Hartung 1994). These dust particles contain a large number of colony forming units (cfus) of aerobically growing bacteria capable of inducing a significant burden to the respiratory tract of both man and animals. Table 1 signifies species-wise fluctuation of air borne organisms and dust in different animal housing systems. Apart from these, particulates containing biochemical compounds, viz. aflatoxins, mycotoxins and endotoxins along with microorganisms like bacteria, viruses, fungi and actinomycetes called bio-aerosols are also

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Table 1. Quantitative estimates for dust and air-borne microorganisms in different species housing systems

Species	Housing	Concentration (mg/m^3)	Concentration (cfu^{-1})
Dairy cattle	General	0.6	58–212
Pig	General	3–22	354–2000
Turkey	Floor housing	4–21	360–3781
Broiler	Floor housing	6.2	850–2983
Layer	Battery	1–51	1907–22044

Source: Hartung (1994)

Table 2. Some estimates of air-borne microorganisms in different species housing systems

Species	Concentration (cfu^{-1})
Bovine	58 –212
Swine	354–2000
Broiler	850–2983
Layer (caged)	360–3781
Layer (litter)	1907–22044

Source: Hartung (1994)

concentrated in and around animal feeding systems. They are known to cause allergic and immunological reactions and upper respiratory tract infections both in human beings and animals. The effects of dust, microorganisms, gases and toxins should not be looked in isolation because dust is often the carrier of these potentially hazardous substances. Rylander (1996) detected endotoxin concentration of 3040 ng/m^3 in a swine house, sufficient enough to cause respiratory, digestive and allergic problems. Keeping pigs in particulate free environment enabled them to attain marketing weight eight days earlier than control group. The impact is even more pronounced in sensitive breeds of dairy cattle and equine.

Influence of pollution on human and animal health: Pollution of the environment has a considerable influence on health and physiology of man and livestock (Patra and Swarup 2000). Epidemiological evidence available from urban settings indicates that exposure to increased levels of particulates, pesticides, heavy metals, fluorine and other agro-chemicals are the major causes of environmental toxicity that may result in poor immune system leading to reduced resistance, especially when animals are housed under improper conditions. As per the scientific literature, heavy mortality in bovines in Punjab (Sidhu *et al.* 1994), Delhi and Rajasthan (Swarup and Dwivedi 2002) due to lead toxicosis; death of livestock during Bhopal tragedy due to accidental leakage and severe industrial fluorosis in sheep in Rajasthan (Patra *et al.* 2001a) and ammonia toxicity in dairy industry (Al *et al.* 2003) are few of the several examples of industrial pollution in domestic animals. These epizootics of environmental pollution had an adverse effect on human and animal health causing cardio-pulmonary diseases, viz. chronic obstructive pulmonary disease, hypersensitive pneumonia and chronic heart disease in human beings and allergic diseases such as rhinitis, alveolitis and asthma in animals. Yet another potent impact of pollution on animal and human health is unorganized abattoirs. Most abattoirs in India, viz. Aligarh (UP), Saharanpur (UP) and Bhilai (Chhattisgarh) are in a very shabby condition. The skin, hide and bones of animals of dead animals are lying in open space attracting stray animals and birds and creating menace to both human and animal life. Even the cases requiring obstetrical intervention like fetotomy procedures and/or caesarean section, can pollute the environment if the carcass and flesh of dead fetuses is not properly decomposed. This is more commonly seen while handing the animals with fetal monstrosities like hydrocephalus (Singh and Brar 2008), amorphous globosus (Singh *et al.* 2009b) and perocephalus brachyrhynchus (Singh *et al.* 2009a) etc. Apart from these, abortions in pregnant animals due to zoonotic diseases if not properly buried can pose serious threats to environment ecology. While most species vary in their sensitivity to toxic pollution, majority have their natural instinct and behavior to protect them from environmental hazard. Dogs for instance take emetics to protect themselves, large ruminants generally reject certain harmful plants and fish pattern of avoidance of contaminated water is used as an indicator of water pollution. Pheasants are good indicators of healthy ecosystem (Anonymous 2004). In general, the impact of pollution on animals results in huge economic losses and ecological consequences.

Volatile organic components emanating from livestock production system and their impact on health: The rapid propagation of concentrated livestock feeding system is associated with emission of certain gaseous pollutants affecting both health and production. The microbial activity on organic substrates in animal waste also results into soluble or gaseous waste products (Fig. 1). Some of the gaseous pollutants and their potential health hazards are given below:

Carbon dioxide: An adult bovine produces about 4000 kg of CO_2, a man up to 300 kg, a pig about 450 kg and a sheep up to 400 kg CO_2 in a year.

Methane: Hazardous effect of methane tune over 21 fold compared to CO_2. It is formed as a result of anaerobic digestion in ruminants. The rate at which they produce gas ranges between 2 to 12% of their gross energy intake. Johnson and Johnson (1995) reported that ruminant livestock produce nearly 250 to 500 liters of methane per day potentially accounting for 2% of the global warming that may occur in the next 50 to 100 years' time since this gas has detrimental effects on ozone layer causing ecological imbalance of greenhouse environment.

Nitrous oxide: It is the third most common greenhouse gas. It is also an 'ozone depleting' substance, causing damage to ozone layer. Other forms of nitrous oxides include nitrous acid and nitric acid. EPA set standards for NO_2 in 1998 at 0.053 parts per million. Major release of nitrous oxide is from agriculture, road transport, power generation and production of acidic products and chemicals. Wide variety of biological sources in soil and water, microbial processes of nitrification and de-nitrification also produce it naturally. In dairy industry, it is used as a mixing and foaming agent as it is bacteriostatic and leaves no taste and odor.

Carbon monoxide: It is formed when carbon in fuel is not burnt completely. A major component of motor vehicle exhaust, carbon monoxide contributes nearly 56% of all emission. Non-road engines and vehicles also contribute about 22% of carbon monoxide production. In India, residential wood burning, forest fires, woodstoves, gas stoves, cigarette smoke and invented gas heaters are the major sources of carbon monoxide release in house holding systems. In addition, it also contributes toward the formation of ground level ozone smog.

Sulphur dioxide: It is a major pollutant in the urban air produced from combustion of sulfur containing fossil fuel, smelting of *Sulphur* containing ores and other industrial processes. In the atmosphere, *Sulphur* dioxide is further oxidized into *Sulphur* trioxide @ 0.5–10% per hour resulting in the formation of aerosols of sulphuric acid in the presence of moisture (WHO 1987). Together, *Sulphur* dioxide and acid aerosols with other pollutants in droplets or solid particles produce sulphurous smog that is highly detrimental to livestock and human health, inducing respiratory problems.

Hydrogen sulphide (H_2S): H_2S is produced from the metabolism of cysteine, a sulphur containing amino acid in livestock waste. In ruminants, inorganic sulfates may also be reduced to H_2S anaerobically in the gastro-intestinal tract. The odor detection threshold for H_2S was reported to range from 0.5 to 30 parts per billion while the irritant threshold ranged between 2.5 to 20 parts per million (Schiffman *et al.* 2001). Previous studies have reported fatal toxicities in the communities living in the vicinity of H_2S producing units (Campagna *et al.* 2000). However, in no case the H_2S concentrations must exceed five parts per billion for half hour (WHO 1987).

Ammonia: It is formed as a result of microbial degradation of the nitrogen containing compounds, including animal manure and dead animals. Dairy animals consume a considerable amount of protein and other nitrogenous substances, a large portion of which is lost in faeces and urine. Ammonia concentration upto 22.7 ppm, 29.3 ppm, 13.7 ppm, 72.9 ppm, 56.3 ppm and 43.7 ppm have been recorded in dairy, beef cattle, calf, layers, broilers and swine confinement facilities, respectively (Koerkamp *et al.* 1998). In poultry, decrease feed consumption and egg production; thin shelled eggs and poor live birth weight are common outcomes of ammonia toxicity (Miner 1973). Therefore, elevated levels of ammonia have adverse health effects both in animals and humans.

Fluorinated gases: Hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride are the main synthetic greenhouse gases emitted through industrial processes. These gases are replaced by fluorinated agents as they are ozone depleting substances and have a very high global warming potential.

Heavy metal toxicity in livestock and human beings: Environmental pollution with heavy metals imparts serious health problems both in humans as well as domestic animals. Various anthropogenic activities such as mining and metallurgy, industry and transport sectors and fossil fuel burning distribute toxic heavy metals into the environment that remain for considerable period of time and result in ecological imbalance. These toxicants tend to accumulate in the vital organs of the body and exert adverse effects (Liu 2003).

Arsenic: It is a highly toxic element, released into the environment through agricultural usage and industrial processes (Ishinishi *et al.* 2004). Ground water contamination with arsenic is an important cause of poisoning in several countries, viz. Argentina, Hungary, Vietnam, Taiwan, Japan and India (Rahman *et al.* 2001). Occurrence of arsenic toxicity due to industrial pollution has been reported in cattle and swine as well as in occupational laborers (Kabir and Bilgi 1993). In cattle, clinical symptoms of arsenic poisoning vary from gastrointestinal to nervous signs. Acute arsenic toxicity is manifested by abdominal respiratory distress, ruminal stasis, restlessness, pain, vomition, dehydration, skin lesions like spotted melanosis, leucomelanosis, hyperkeratosis, gangrenous extremities, cognitive impairments as well as cancers of different organs in human beings (Rahman *et al.* 2001). In chronic cases, conjuctival and mucosal erythema, buccal ulceration, weight loss, capricious appetite and reduced milk yield are commonly observed signs in bovines (Radostits *et al.* 2000).

Mercury: Toxicity of mercury is an important cause of lethal effects in human beings and animals characterized by high morbidity and mortality. The metal is released in environment from both anthropogenic and natural sources. Sources including waste disposal coal combustion, metal production, etc. discharge substantial quantities of mercury in the environment. While air pollution from mercury results due to combustion of diesel, jet fuel and coal burning, water contamination arises from dental clinics, thermometers and gold mining. Mercury poisoning imposes hazardous impact on wide variety of species, viz. fish, cats, birds, dogs, and pigs including human population. Digestive problems, kidney damage, mental retardation in children, blindness and deafness are common clinical manifestations in human population. The cats are affected most and hence, the disease is also called as 'dancing-cat-disease' since the affected cats would salivate and stagger in a zig-zag manner and finally collapse. Similarly, Minimata disaster is another example of mercury poisoning that dates back to mid-fifties (Harada

1978). In yet another study, Ramanathan *et al.* (2002) recovered high concentrations of mercury in the peri-urban areas of some metropolitan cities where paper making industries were located causing serious threat to both human and animal life.

Lead (Pb): It is a widely distributed ecological pollutant with no well-defined biological action in the body. Contaminants like machinery grease, empty paint tins, combustion of coal, petrol and power industry, cement production, metallurgy and discarded batteries when ingested by grazing ruminants can cause plumbism (Choudhary and Naha 2002). The animals browsing in the vicinity of metallurgic complexes and busy roads are most affected. Clinical signs include hyper-salivation, behavioral problems, miscarriages, decreased sperm formation, memory loss and learning difficulties, head pressing, in-coordinated movement, blindness, high blood pressure and depression that often results in high mortality in animals (Dwivedi *et al.* 2001). Shortening of gravidity, premature deliveries, decrease birth weight and retardation of mental development are other symptoms associated with lead toxicity in human (Smirjakova *et al.* 2005).

Cadmium (Cd): It is a volatile element released into the environment through production of plastic and batteries and electroplating and manufacture of alloys. Its presence in living organisms is unwanted and harmful. Nriagu and Pacyna (1988) reported that the dust and waste water from phosphate rocks, fertilizers, coal and oils also contribute to discharge of nearly 30,000 tons cd into environment per year from human activities. Introduction of sewage sludge, fertilizers and other organic wastes to agricultural land elevates cadmium concentration in soil. An increase level of cd in air, water and soil increases its uptake by living organisms through food chain. In animals, it causes softening of bones as it disturbs calcium metabolism and decreased productivity. Since it is a cumulative poison, prolonged uptake of cd interferes with normal functioning of kidney.

Fluorine (Fl): Continuous ingestion of fluoride results in chronic fluoride toxicity commonly referred as fluorosis. Fluorine poisoning is common in Andhra Pradesh and Punjab. Lameness, inability to masticate food materials, poor weight bearing, reduced feed conversion efficiency and poor digestibility are the clinical symptoms observed in animals suffering from fluorosis. While dental fluorosis reveals signs of mottling of tooth enamel with severe osteosclerosis, hypoplasia, hypocalcification and increased wear of teeth, skeletal fluorosis is characterized by hyperosteosis, osteopetrosis and osteoporosis. Incidence of fluorosis in livestock mainly is due to fluoride emission from different industrial and natural sources (Swarup and Dwivedi 2002).

Selenium (Se): Selenium toxicity mainly results from industries emitting fly ash especially soft coal. In dairy ruminants, poisoning due to Se is characterized by alopecia and foot scaling in animals. Dhillon *et al.* (1990) reported Se excess as one of the potent factors causing degnala disease and affecting cattle and buffaloes population in the Indian sub-continent. Induced infertility as a result of selenium toxicity has been observed in affected surviving buffaloes resulting in serious economic constraints to progressive dairy farmers (Atwal 2000). In birds, the most notable symptoms were severe abnormal-loss of feathers, stillborn or deformed offsprings, muscle atrophy, liver degeneration and emaciation (Fleming 1996).

Impact of pollution and production loss: The effect of any kind of pollution in animal management systems is associated with significant financial losses owing to poor health and reduced productivity. This may adversely affect the quality of milk, meat or eggs and at times may render these value added products unfit for human consumption. Heavy fiscal losses to the tune of 700 million dollars due to pollution in dairy, equine and poultry industry have been reported previously that account for serious economic constraints to livestock farmer (Schwabe 1984). In this context, pollution from different sources and its impact on human and livestock health and production is discussed below.

Pollution from industries: With rapid urbanization and mechanization in the past decade and a half particularly in developing countries like India, pollution from industries affected both human and animal health leading to production losses. Situation is even worse in metros like Delhi, Mumbai, Calcutta, Chennai and Bangalore. The severity of pollution depends upon presence of interacting chemicals, extent of exposure, species, age and physiology of exposed livestock and kind of pollution. Nutrition compromised animals are more vulnerable to the effects of pollution (Swarup and Dwivedi 1998). In India, transport sectors and industries are key factors for their contribution towards pollution. A few of them include integrated iron and steel, oil refineries, tanneries, drugs and pharmaceuticals, pesticides, cement smelters, thermal power plants, fertilizers, petro-chemicals and dye and dye intermediates. Some examples of industrial pollutants are oxidants and ozone, toxic heavy metals, halogen gases, volatile hydrocarbons and oxides of sulfur, nitrogen and carbon.

Impact of air pollution: Automobile, industries and thermal power plants are the major contributors of the atmospheric pollutant load. In addition to these, quarrying and agriculture are the other sources of air pollution. The primary pollutants emitted in atmosphere include oxides of sulfur and nitrogen hydrocarbon, carbon dioxide, carbon monoxide and volatile organic substances. Other secondary pollutants such as nitric acid, sulfuric acid, ozone and peroxyacetyl nitrates (PANs) are also formed in the atmosphere. Together, the primary and secondary pollutants produce photochemical smog constituents that have devastating effect on livestock, plants and human beings. Rao (1984) observed that eye and respiratory irritation are common outcomes of air pollution and may occur even at a very low concentration (0.5 mg/kg). Together, ozone, PANs and oxides of nitrogen and sulfur induce lung and skin cancer in human beings and animals. Appreciable quantities of heavy metals released in air from smelting of metals, waste incineration and automobile smoke led to high pressure atrophy of bronchial and alveolar ducts followed by death (Swarup *et al.* 1998).

Water pollution and its effects: Both anthropogenic and natural sources are responsible for water pollution. The major water polluting industries are textile and chemical, leather, pulp and paper and tanneries. The main pollutants of water pathways include toxic nitrates, fluorides, heavy metals, pesticides and fertilizers. These pollutants change pH, temperature, biological and chemical oxygen demand of water. Swarup (2002) reported that release of effluents from industries into the sea resulted in high toxic metal concentration in marine fish threatening to their life. In addition, industrial wastes also contribute to higher content of fluoride, nitrites and nitrates, cyanide, pesticides and other toxicants in water. Dumping of municipal solid waste adversely affected the ground water quality in Karnataka state (Naik *et al.* 2007). Ray and Bhattacharya (1989) depicted that ground water in several districts of Punjab, Haryana, Uttar Pradesh, Rajasthan, Tamil Nadu and Madhya Pradesh had higher nitrate contents due to excessive use of nitrogenous fertilizers. In animals, the upper safe limit of nitrate in drinking water is 440 mg per liter. Acute toxicity has been reported to occur at a level higher than 1500 mg per liter. In cattle, feeding of Napier *Bajra* hybrid irrigated with wastewater can also lead to acute nitrite poisoning. Clinical indications of nitrate poisoning include respiratory distress, gastroenteritis, anoxic anemia followed by death. Cyanide (Cn) is yet another potentially toxic water pollutant. Recently, Chhabra (2002) detected high Cn content in ground water samples from the industrial city of Ludhiana due to effluent from electroplating units.

Influence of soil pollution: Soil and land pollution usually result from disposal of solid, semi-solid and chemical wastes from agricultural, industrial and mining sources. Continuous disposal of wastes at a specific site general1y leads to accumulation of enormous quantity of pollutants for a substantial period of time affecting human and animal life. In India, the non-degradable portion constitutes nearly 15–44.2% of the total solid wastes. Presence of these wastes in grazing areas is highly detrimental, especially in bovine due to their indiscriminate feeding habits and often results in gastro-intestinal disorders, ultimately leading to high mortality. Sharp objects such as nails and wire are the common outcomes of traumatic peri-carditis and traumatic reticulo-peritonitis in ruminants. Certain solid wastes like discarded batteries also account for lead poisoning in dairy animals. Furthermore, use of polythene, rubber and plastic bags by urban society inorder to dispose garbage and wastes also resulted in gastro-intestinal problems in voracious eaters like cattle (Patra and Swarup 2000). Another potent metal of toxic significance is cadmium (cd). Considerable fraction of cd, released from industrial processes such as electroplating and alloy manufacturing and plastic production, is deposited over land thereby causing toxicity in farm animals.

Pollution of vegetation and its effects: Plant pollution is commonly associated with soil and airborne pollutants. Irrigation of forage crops with contaminated water and spray with insecticide and/or fertilizer is a common cause of pollution of vegetation. Heavy application of nitrogen fertilizers can decrease concentrations of molybdenum, cobalt, copper, zinc and manganese in pasture. Deficiencies of these elements may be associated with impaired reproduction and production traits (Radostits *et al.* 2000). In bovines, several incidences of fluorosis have been accounted for pollution of vegetation from industrial sources (Swarup and Dwivedi 2002). Fleming (1996) opined that fluoride embedded air borne particulates tend to settle over leafy surface of plants. Consumption of this herbage by stray ruminants causes fluorosis in them. In addition, wastes from chemical and mining industries may contain high profile of toxic elements and when these are deposited on land, elevated metal content in soil and plants have been found to cause toxicity in livestock.

Impact of pollution from radioactive materials: The pollution from radioactive materials can cause significant impact on livestock and human health. Radioactive materials like uranium, thorium, iodine, radium and plutonium are radiotoxic and chemotoxic that can cause terratogenecity, cardiotoxicity, leukemia, thyroid cancer, hair loss and impaired reproduction. Nowadays these are extensively being used in making of nuclear weapons, chemotherapy, power generation and estimation of hormones. History of pollution form radioactive material dates back to First World War when United States first used nuclear bomb against Japan. The impact was so high that people and livestock were severely affected upto decades thereafter. Explosion of chernobyl nuclear power plant in the year 1986 resulted in widespread radioactive pollution over Russia, Ukraine, Poland, Czech Republic and Scandinavian countries. Over five million people were affected by radioactive contamination through radiation sickness, induced leukemia and other solid cancers. Various nuclear tests performed, viz. Australia (1995), China (1996), France (1996), Pokhran (1998, India), Pakistan (1998) and more recently North Korea (2009) should also be prohibited as they directly or indirectly affect the nature. Accordingly, Controlled Test Ban Treaty (CTBT) and/or Nuclear Test Ban Treaty (NTBT) were initiated to limit such tests in different countries. Even though India has signed the nuclear treaty under International Atomic Energy Agency (IAEA), there is considerable interest in reducing greenhouse gas emissions in the country. Lately, G8 summit in L'Aquila, Italy (2009) gave a strong action on climate change created by G8 countries and conferred appropriate measures to tackle as only political commitment at the highest level can prevent a human catastrophe. Recently, Stojanovic *et al.* (2009) reported uptake and accumulation of uranium in plants native to uranium mine sites could be life threatening if consumed by humans and animals.

Effect of pollution from fossil fuel-fired electric power plants: Fossil fuel-fired electric power plants constitute the largest source of air pollution. They are a major contributor of carbon dioxide emissions that result in climate change and inturn affect human and livestock health. In a study by United States Department of Energy (DOE 2000), electric power plants produced approximately 2.2 billion tons of carbon dioxide, 12 million tons of sulfur dioxide and 7 million tons of nitrogen oxide, globally. The situation is worse in United States itself wherein nearly 77% fossil fuel-fired power plants are not subject to pollution control under the Clean Air Act's New Source Review requirements. To meet future energy demand growth and replace older or inefficient units, the plants were developed with newer technology and attainable efficiency. These include pulverized coal combustion (PCC) with both sub-critical and supercritical (very high pressure and temperature) steam turbine cycles, coal-fuelled integrated gasification combined cycle plants (IGCC) and natural gas fired combined cycle plant (NGCC). These plants have very low conventional pollutant emissions (sulfur dioxide, nitrogen oxide and carbon dioxide), high efficiency and are available at commercially acceptable cost. A few of these plants that have been exempted from Clean Air Act requirements include sea water cooled ultra-supercritical plant, Nordjyllandsvaerket, Denmark; lignite-fired inland ultra-supercritical PCC plant, Niederaussem, Germany; sub-bituminous coal-fired inland supercritical plant, Genesee, Canada; bituminous coal-fired coastal ultra-supercritical plant, Isogo, Japan; bituminous coal-fired coastal supercritical PCC plant, Younghung, Republic of Korea; clean coal-fired inland supercritical PCC plant, Wangqu, China; high ash bituminous coal-fired inland PCC plant, Suratgarh, India and high ash bituminous coal-fired PCC plant, Majuba, South Africa.

Clinical impact of pollution

Acid rain: It is primarily formed by the release of nitrogen and sulfur in the atmosphere due to combustion of coal and oil by power plants and automobiles that could be life threatening to man, animals and aquatic ecosystems as well. Acid rain is a result of both natural sources like volcanoes and decaying vegetation and man-made sources such as sulfur and nitrous oxides resulting from burning of fossil fuels in automobiles and power generation using coal. The toxic effect of acid rain occurs as a result of acidity itself. Another important compound that results in acid rain is ammonia. It is a common outcome of disposal of large quantity of unprocessed manure in animal production systems. Hadina *et al.* (2001) reported that ammonia produces acid rain and is harmful to both livestock and man and, disturbing ecological balance. When these gases come in contact with moisture in air and oxygen, they form acidic compounds which get deposited as both wet and dry deposits to pollute soil and water.

Wet deposits: It is a combination of acid rain, fog and snow. As this moisture containing acidic water flows over the ground, it affects plant and animal life. These effects depend on the acidity of water and buffering capacity of soil.

Dry deposits: When air is dry, acid chemicals get incorporated in suspended dust or smoke and fall on ground as dry deposits. Nearly half of the acidity in the atmosphere falls back to earth as dry deposits.

Noise pollution: Unwanted sound is called 'noise' and pollution due to noise is an important ecological problem. Major sources of noise are transport and industries. In terms of frequency and loudness, a sound may range from 10 decibel (just audible) to 120 decibel (painfully loud). On an average traffic generates moderate noise of about 70 decibel where as newspaper press, farm tractor, milling machine and train whistle creates very loud sound in the range of 90–130 decibel. Similarly, burning crackers and fireworks especially during festivals and marriages in the modern society create strong fear and fright amongst animals. Zhou (1995) reported continuous noise (73.4 decibel) from a factory as a predominant cause of dysphoria, decreased milk yield and abortion in cows. In another study, Nosal and Bigery (2004) observed that an intensity of > 65 decibel noise produced during milking from lactating cows may adversely affect the milk yield. Besides, variety of physiological damages that affect auditory and central nervous system in human beings and livestock also result from sound pollution. Air traffic causes significant noise pollution when airplanes fly. They create supersonic boom, which could be detrimental to the health of livestock. Likewise, ship traffic is a possible cause of underwater noise in the range of 10 – 500 hertz band, disrupting normal marine life (Shaw 1978).

Chemical pollution: A number of chemical pollutants released from industries are capable of inducing sub-clinical impact in a population exposed for a longer period. Bioaccumulation of heavy metals especially cadmium, mercury and lead in milk, meat and other tissues of animals living in industrial vicinity have evoked a great concern in the recent past. These pollutants disrupt several enzyme systems in the body. Clinico-epidemiological studies in India and globally have shown that exposure to industrial pollutants can lead to endocrine disruption, reproductive disorders, carcinogencity, teratogenecity, cardiotoxicity and enzyme inhibition in human and livestock (Schantz and Widholm 2001). High prevalence of abortions, still births, hypertension and irregular estrous cycles have been reported in women exposed to lead and cadmium for longer duration (Vaziri *et al.* 2001). In males, these chemicals affect hypothalamohypophyseal-thyriod axis and cause thyroid dysfunction (Wade *et al.* 2002). Fluoride exposure also impairs reproductive functions causing frequent estrous cycles, sterility, birth of weak calves, still births and induces teratogenicity (Swarup and Singh 1989). Another feature of chemical pollution is excessive formation of free radicals. Tissue and sub-cellular injury caused due to excess production of free radical precipitates a condition termed as oxidative stress. Toxic damage exerted by heavy metals such as cadmium, arsenic and lead is considered to be one of the potent causes of oxidative stress (Patra *et al.* 2001b). Recently, ionizing radiations through radioactive material has become a topic of major concern. Radioactive contamination could be of natural (uranium, radium, thorium rubidium, radiocarbon etc.) and artificial origin (radioactive discharges from hospitals and laboratories, nuclear reactors) causing serious environmental pollution and affecting livestock health. Farm animals are most vulnerable to these pollutants because of their grazing habits. Both reproductive and productive traits in dairy animals are affected by exposure to radiation that may eventually prove fatal.

Pesticide pollution: Approximately 25 million workers in developing countries suffer from pesticide poisoning yearly (McCauley *et al.* 2006). It is an important tool used for pest control in agricultural operations. However, extensive use in agriculture and owing to their toxic potential incriminated them as the most common cause of toxicity in livestock and man (Swarup 2002). Principle entry of pesticides in animal premises is due to their indiscriminate use in veterinary practices. Insecticides and fungicides are common pesticide contaminating livestock. Meral and Boghra (2004) reported high levels of pesticide in milk and milk products that may be associated with health hazards in man and animals. Pesticides are also called as endocrine disrupting chemicals leading to reproductive, immunotoxic and cardiogenic effects and miscarriages (Engel *et al.* 2000). Additionally, pesticide exposure is associated with respiratory problems, memory disorders, dermatological disorders (Arcury *et al.* 2003), depression (Brunstrom *et al.* 2003), neurological disorders and breast cancer (Beseler *et al.* 2008).

Residual effects

Heavy metal residues: Toxic metal contaminants enter in animal systems through water, air and soil pollution and persevere for longer duration even after withdrawal of exposure. Kamel (2003) observed increase lead concentrations in the tissues of animals up to 12 – 18 months after cessation of exposure. Similarly, (Patra *et al.* 2001a) reported high levels of lead (1.13±0.38 ppm) in milk even after six weeks of exposure discontinuation in buffaloes suffering from acute industrial plumbism. Likewise in urban and peri-urban areas, elevated levels of lead in blood and milk have been well documented (Swarup *et al.* 2005). These findings clearly indicate that problem of toxic metal residues can be more alarming and may be associated with sub-clinical health hazards in man and animals.

Pesticide residue: Residues of pesticide and their metabolites have been detected in dairy and poultry products (Kotwal *et al.* 2004). Extensive and indiscriminate use of pesticides in agriculture and veterinary practices are the principal source of its exposure. Residues of organochlorine chemicals in animal and human tissues disrupt mammalian oocyte and follicle physiology resulting in impaired reproduction (Pocar *et al.* 2003). Similarly, residues of dichlorodiphenyl trichloroethane (DDT), hexa-chlorocyclohexane (HCH) and cyclodiene in human fat and breast milk resulted in widespread contamination of the ecosystem and therefore the potential of possible health hazards (Aulakh *et al.* 2003, 2007). Galloway and Handy (2003) documented depress immunity followed by increase susceptibility to infectious agents with organophosphorus pesticides. Milk samples collected from areas where pesticides had reportedly been used to kill mosquitoes revealed 25% residue levels of pesticide above maximum residual limit (Surendranath *et al.* 2002). Even the aquatic life is not escaped from the harmful effects of pesticide pollution. Recently, Ogwok *et al.* (2009) observed increase concentrations of total residual dichlorodiphenyltrichloroethane (DDTE), endosulfan, heptachlor, hexachlorocyclohexane, hexachlorobenzene and aldrin in Nile perch fish (*Lates niloticus*) which is a native of Lake Victoria in Africa.

Drug residue: Resistance to chemotherapeutic agents is largely a result of overuse or misuse of drugs in hospitals and community in general. Barton (2000) opined increase resistance in man due to active transfer of resistant genes from animal to human beings through food chain. Animal drugs and chemicals used for therapeutic and prophylactic purposes have toxic significance for consumer and influence the quality of milk and milk products. Another common example of drug residual effect is extinction of Indian vulture (*Gyps indicus*). Wide range of hypotheses, viz. food unavailability, pesticide toxification, infectious diseases and poisoning have been put forward to explain the population decline (Prakash 1999). Although, researchers are still not able to reach a consensus on single underlying factor for population decline of vultures, recent reports have documented strong correlation of contamination of food web with diclofenac residues, leading to renal diseases and mortality in vulture (Oaks *et al.* 2004). Therefore, untoward drug residual impact can only be avoided with enforcement of drug registration, observation of withdrawal time, development of screening methods and live animal tests amongst people (Lee *et al.* 2001).

Emerging environmental challenges: In addition to the items mentioned previously, certain topics remain on the ‘radar screen’ of national regulatory bodies. Antibiotic residues, pathogens, endocrine disruptors and global warming are just few of the many issues that have major implications for animal agriculture. Food safety has received a tremendous amount of attention. Securing our food from any source of threat will continue to be a critical priority for consumers. While more recent events have created awareness of agro-terrorism, especially where food and water supplies have been compromised, possibly due to agricultural practices and pathogens emitted as a result of livestock rearing. Previous studies indicate the potential development of antibiotic resistance as a result of consumption of animal products (Arvanitidou *et al.* 1998). High concentration of tylosin (8.1±5.3 ng/l) has been found in swine barns by Zahn *et al.* (2001). These data suggest that approximately 30% of the administered dose is present in bioactive form in the building premises. Therefore, broad-scale efforts should be made to limit the therapeutic use of antibiotics in the animal industry. Another important contribution of pollution especially air is towards global warming. Global warming is a popular scientific theory relating to heating up of earth. It has critics, but there is some evidence that it could be happening, and it certainly seems logical. If global warming turns out to be real and likely will, it could cause serious problems. Rise in temperature of the entire earth by only a few degrees may lead to melting of more polar ice caps. This would likely cause flooding in coastal cities as the sea level rose worldwide and may impose serious threat to both human and animal life. A critical example of the effect of environmental change on sea level is Tsunami. It is a wide ranging wavelength and long surface wave generated by coastal earthquake as a result of ecological alteration (Mishra *et al.* 2007). The Tsunamis of December, 2004 in India and March, 2011 in Japan were unique in the history for its magnitude and devastation. It led to massive loss of human and animal lives in the coastal areas of both the countries. Current investigation has revealed that a number of common pollutants are increasing the natural greenhouse effect. These pollutants, called greenhouse gases, come from natural processes. A major contribution for instance is from livestock sources in the form of carbon dioxide, methane gas and nitrous oxide. Johnson and Johnson (1995) reported that 67% of global greenhouse gas emissions are from anthropogenic sources with livestock contributing 13% of the total emissions (Figure 1a and 1b). In addition to emissions as a result of eructation in ruminants, methane results from the anaerobic decomposition of manure during storage. The introduction of ionophores into ruminant diets

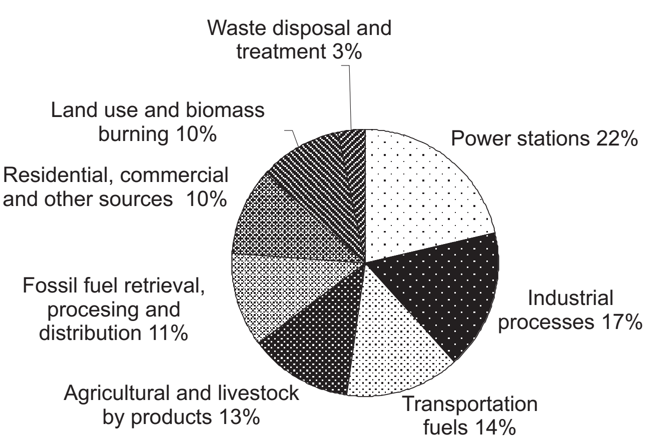

Fig 1a. Annual green house emission by different sectors (Johnson and Johnson 1995).

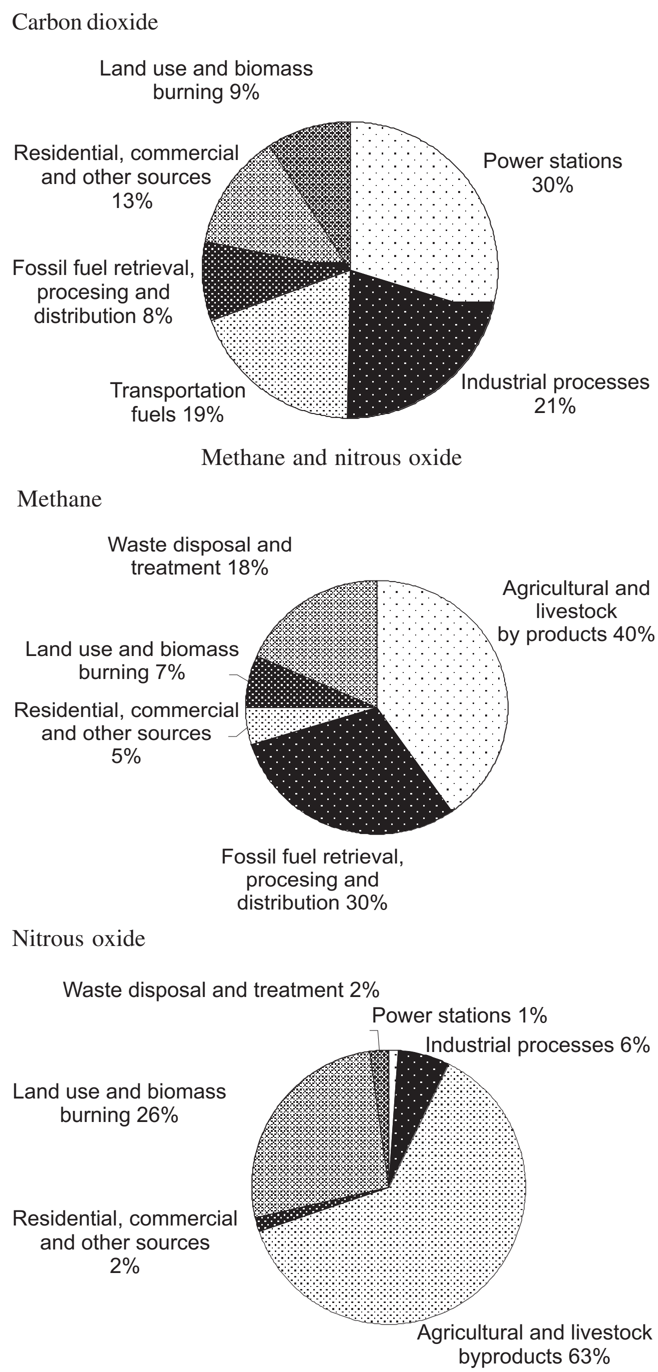

Fig. 1b. Directly emitted natural and anthropogenic global carbon dioxide, methane and nitrous oxide emissions by principal source categories (EPA 1998).

has made considerable gains towards reducing methane emissions from large ruminants. If approved for use in lactating animals, greater reduction in total methane emission from the animal industry is eminent. Molecular techniques such as real time polymerase chain reactions (PCR) and restriction fragment length polymorphism (RFLP) can be used on rumen content samples to examine and quantify methanogenic microbial populations in the rumen of cattle. Furthermore, different breeds can be compared to determine whether or not genetic component(s) associated with the variation in composition of such microbial populations. New research efforts continue to identify methods of reducing methanogenic activity in the rumen without compromising animal performance (Miller and Wolin 2001). There is a considerable need to develop and refine measurement techniques for ambient concentrations of these pollutants as well as development of procedures to identify sources of pollutants. The day may come when animal agriculture is targeted as a primary contributor to environmental pollution. Thus, additional management strategies will be needed to curtail the excretion of pollutants like antibiotic residue, hormones and pathogens. The involvement of environmental and reproductive scientists and animal management specialists will be instrumental to meet such standards.

Pollution and greenhouse effect: The greenhouse effect actually comes from a combination of air pollution and massive tree-cutting. In a greenhouse, heat from the sun enters the earth's atmosphere. This heat in the form of infra-red light bounces and heads back up toward the atmosphere. The atmosphere then allows major portion of this heat to escape, but reflects back some portion. This heat remains bouncing within the greenhouse (Fig. 2). In the prehistoric times, the atmosphere remained relatively constant, and so heat was released or retained in a regular manner. However, as the technology advanced, fabrication of big polluting machines took place. These machines, in the burning of fossil fuels quickly added carbon monoxide and carbon dioxide into the atmosphere that readily retain heat. With more of these gases in the atmosphere, more heat accumulated in the earth and its atmosphere, and a warming trend began. To fix this, we need to reduce the emissions of pollution. Furthermore, this wouldn't be quite so bad because of trees. These trees, as part of the process of photosynthesis, take in carbon dioxide and release oxygen that solve the excess carbon dioxide problem. However, the trees are rapidly disappearing. The forests are rapidly being cut down for many reasons nowadays such as wood for building and furniture, paper products, to clear space for housing and for livestock grazing. Nevertheless, our chance at fixing greenhouse effect problem is being cut down. We must use recycled goods to keep trees available for fixing the carbon dioxide problem we have already made. At the same time we must reduce our emissions of carbon dioxide, to ensure that planetary temperatures remain stable.

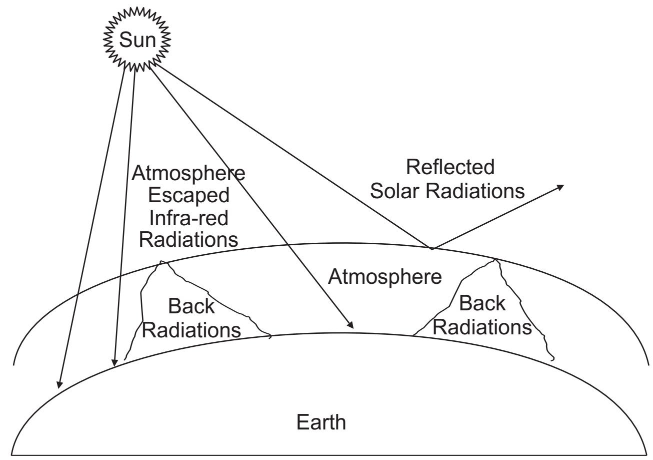

Fig. 2. Current understanding of greenhouse effect as a regulator of climate change

Current trends and future research needs: Animal and human health hazards along with rising pressures on land, water and air resources due to industrialization and mechanization in recent years have focused global attention on finding new ways to manage and sustain the ecosystem. Although, there has been growing interest amongst scientists in the epidemiological studies pertaining to pollution, still, several gaps exist in this field that needs critical attention of veterinary researchers and all concerned with livestock health and industry. These is a dire need to establish legal regulations and laws for risk assessment and management in order to protect the health of livestock and human beings. Biotechnology is another essential tool in this venture that can provide new approaches to manage, preserve and restore the environment. Biotechnology can be used to generate biodegradable materials from renewable sources and develop eco-friendly manufacturing and disposal processes. The roots of several plants serve as host reservoir for toxic metals. Consequently, phycoremediation can be used as an alternative method to decontaminate soil and make environment clean and green. Furthermore, rumen manipulations to reduce methane gas eructation are thrust areas for newer research. Therefore, need-based cost-effective mitigation strategies to reduce methane emissions from livestock need to be developed. Still more effective is a term called 'renewable energy'. Renewable energy is the energy source that is regenerative for all practical purposes, virtually inexhaustible. It includes solar energy, wind energy, hydropower, biomass (derived from plants), geothermal energy (heat from the earth), and ocean energy. Renewable energy resources can supply energy for heating and cooling buildings, electricity generation, heat for industrial processes and fuels for transportation. The increased use of renewable energy can reduce the burning of fossil fuels (coal, petroleum and natural gas), eliminating associated air pollution and carbon dioxide emissions and contributing towards national energy independence and economic and political security. Aerosols are other compounds that can help to cool the earth. The aerosols come from natural sources such as volcanoes but a substantial load also comes from human sources like the soot from oil and wood burning. They are tiny particles of sulfur or carbon held in the air and play significant role in climate change by scattering radiation and cooling the troposphere. However, these expected to diminish in the coming decades, since they do not remain in the atmosphere for a long period of time and therefore global warming would accelerate. More tests are clearly required in acceleration and accumulation of aerosols in the atmosphere along with their precise impact on global climate. Afforestation is yet another method to prevent climate change. If everyone plants atleast one sapling in his/her area of vicinity, the condition of deforestation can be reduced to some extent. Therefore, creating awareness among people through slogans like 'Each One Plant One' can help us overcome this problem. Further, construction of modern fossil fuel-fired plants with PCC, IGCC or NGCC technology can also reduce carbon dioxide emissions in the atmosphere. All these must be incorporated in future programs associated with livestock reproduction and production systems vis-à-vis health.

Environmental pollution is a major global problem posing serious risk to livestock and human beings. Industrialization and mechanization in the modern society are the key factors that contribute toward pollution. Various pollutants like toxic metals, drugs and pharmaceuticals, oil refineries cement smelters pesticides, iron and steel, tanneries, pesticides, thermal power plants, fertilizers, petro-chemicals, automobile, industries and thermal power plants affect human and animal health. These pollutants can lead to carcinogencity, reproductive disorders, teratogenecity, cardiotoxicity and enzyme inhibition in human and livestock. A critical need is required to address these problems if we have to make our planet clean and eco-friendly.

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