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Impact of Livestock Waste on Environment and Strategies to Reduce Environmental Contamination – A Review

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ABSTRACT The number of farm animals is increasing day by day globally, which is, although a positive sign for mitigating the widespread hunger and malnutrition, but on the other hand, the growing livestock population is posing a great threat to environment in the form of animal wastes. Animal scientists are focusing more on the sustainable increase in the livestock production systems but are least concerned about the wastes emerging out from the livestock industry and livestock itself. The unconditional use of chemicals in agriculture, livestock farming and allied industries has not only raised an environmental concern but also a health concern for the humans. The excretions from the animals have residues of certain chemicals which are noxious for humans and environment and also certain zoonotic pathogens which are very harmful for human health. The fusion of traditional management procedures with advanced research can better serve the purpose of animal waste management.

INTRODUCTION

According to the United Nations' Food and Agriculture Organization (FAO 2004), Asia has the fastest-developing livestock sector, followed by Latin America and the Caribbean. Consequently the animal waste production also increases day by day in these regions. To give an idea of scale, the planet's population of some 2.5 billion pigs and cattle excrete more than 80 million metric tons (MMT) of waste nitrogen annually. The entire human population, in comparison, produces just over 30 MMT (Koopmans and Duizer 2004). Due to continuous incorporation of nitrogen from urine and faces in air depress the oxygen concentration and causing respiratory diseases. Whereas waste disposal in water not only pollutes it but also cause water borne diseases resulting in shortage of clean drinking water (Hansen and Meres 2002). Human life remains at risk during animal handling and care, especially animal wastes like urine, feces/dung and dead bodies, which are the carriers of pathogens. From these excretes sometimes very complicated diseases like Listeriosis, Leptospirosis, Salmonellosis, Brucellosis and Vibriosis are transmitted to humans (Korner et al. 2003). When the organic matter decomposes, it produces methane gas. Pollutants from unmanaged livestock wastes can degrade the environment, and methane emitted from decomposing manure may contribute to global climate change.

The increasing demand for food leads to a process of intensification in livestock production, which can lead to serious environmental problems if animal waste is not managed properly. In this sense, alternative technologies for good waste management can and must be used, as is the case of bio digesters, which produce biogas and bio fertilizers and are an adequate form of animal waste treatment. The idea of looking at manure as a resource, not a waste, has been central idea much of the more recent thinking on whole subject of good farm management (Burton and Turner 2003). The utilization of livestock waste has many advantages *vis-a-vis* cleaning of the environment, proper manage-

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ment of the waste, prevention of the diseases and also using the same will reduce the costs incurred on the chemical fertilizers to be used in the cultivation of crops (Mahfooz et al. 2006; Matthias 2014).

Objectives

- To understand the waste production by livestock.
- To understand the extent of environmental degradation by livestock waste.
- To check and analyze the remedial measure for livestock waste management.

METHODOLOGY

The review paper has been written by using secondary scientific data obtained from the internet and offline journals whose references are duly mentioned. Further, the critical analysis of impact of livestock waste on environment is done and the conclusions are given below.

OBSERVATIONS AND DISCUSSION

Impact of Animal Waste on Environment

Increasing livestock population is posing threat to the environment through the generation of huge amounts of animal waste. There are cases in the word with tragic and very serious consequences. In 2000, the contamination of drinking water with livestock waste led to several deaths in Canada (Catelo et. al. 2001). The relationship between livestock production and greenhouse gas (GHG) emissions it is widely recognized. According to Steeg and Tibbo (2012) cited by Mathias (2014), agriculture contributes between 59 percent-63 percent of the world's non-carbon dioxide (non-CO_2) GHG emissions, which consists of 84 percent of the global nitrous oxide (N_2O) emissions and 54 percent of the global methane (CH_4) emissions. According to McMichael (2007), livestock production contributes much of the estimated 35 percent of global greenhouse-gas emissions deriving from agriculture and land use. Orheruata and Omoyakhi (2008) have provided the comprehensive list of the hazards arising from the animal wastes which are taken into consideration for writing this review. Keeping the given facts in mind, it is believed that the expansion of livestock production creates the need to deal with subsequent environmental problems and some are summed as:

Air Pollution and Climate Change

Aerial pollutants arising from livestock industry include organic and inorganic dust, pathogens and other micro-organisms as well as gases such as ammonia, nitrous oxide, carbon dioxide, hydrogen sulphide and methane (Harry 1978; Okoli et al. 2006). When the pH of livestock waste increases, the ammonium ion is converted to ammonia gas which easily volatilized to air and increases atmospheric N content (Moore 1998). Ammonia emissions from wet animal droppings were found to coincide with odors, which are nuisance in area of intensive livestock production (Chavez et al. 2004; Cole and Tuck 2002). A high atmospheric concentration of ammonia can results in acidification of land and water surface causing damage to plants and reducing plant biodiversity in natural system. Air pollution and global warming are produced by livestock directly and indirectly. The production of livestock has significantly contributed to the increase levels of CO_2 and other greenhouse gases during the past 250 years (Darwin 2001). About 40 percent of emitted methane is produced by agriculture predominantly by ruminant animals (Rosen Zweig and Hillel 1998). Methane and nitrous oxide are considered significant greenhouse gases due to their efficiency in absorbing infrared radiations. Sommer and Moller (2000) observed that methane and nitrous oxide absorb 26 to 200 times more infrared radiation, respectively than carbon dioxide and contributes to global warming and climate change.

Water Pollution

Animal wastes are spread as slurry over crops and pastures to fertilize the ground and enrich the soil with various forms of nitrogen. If an excess amount of animal droppings are applied to crops that are unable to fully utilize the nitrogen, the residual large nitrate content may leach through the soil to the ground water after harvesting and causes problems. One of the main pathways of field nitrogen loss is through leaching and runoff losses to ground and surface water (Rotz 2004). The resulting leachate and runoff enters the ground water and subsequently the drinking water sources of both human and livestock are polluted by high concentration of nitrates.

Land Degradation

In many countries, prolong heavy grazing contributes to the disappearance of edible plant species and subsequent dominance by either inedible, herbaceous plants or bushes. Livestock impact on the soil can be classified into two broad categories as reported by Whitmore 2001, physical impact of the animal on the soil as it moves around and secondly, the chemical and biological impact of the feces and urine that the animal deposits on the soil. The amount of urine eliminated by a grazing cow is of the order 2 liters applied to an area of about $0.4m^2$ (Addiscoth et al. 1991), which represents an instantaneous application of 400 to 1,200kg N per hectare. Such an amount burns vegetation and is often toxic to plant roots which cannot immediately recover to take the nitrogen (full recovery can take up to 12 months) and the problem worse in areas where animals congregate (Early et al. 1998). Along with nitrogen, excess phosphorus presents special problem, as a result of its low solubility in the soil, contaminates surface water and cause erosion.

Heavy Metals

Large fractions (generally > 90%) of the heavy metals in livestock diets are excreted in manure. A study on soil-crop balances of the heavy metals Cd, Cr, Cu, Hg, Ni, Pb, and Zn in agricultural soils in The Netherlands showed surpluses of all the metals studied (Delahaye et al. 2003). Excess of these heavy metals led to their accumulation in plants and also leaching to surface and ground water. Soils on which pig and poultry manures are continuously applied at high rates accumulate heavy metals jeopardizing the good functioning of the soil, contaminating crops and posing human health risk (Conway and Pretty 1991). There are so many other toxic substances that require attention in livestock production. These substances are antibiotics, hormones, and veterinary medical residues. These substances may have negative effects on food quality, human health and on the health of aquatic ecosystems (Ogbuewu et al. 2012).

Environmental Health Effects of Concentrated Animal Feed Operations (CAFOs)

Though sewage treatment plants are required for human waste, no such treatment facility exists for livestock waste. The most pressing public health issue associated with CAFOs (Concentrated Animal feed operations) stems from the amount of manure they produce. All of the environmental problems with CAFOs have direct impact on human health and welfare for communities that contain large industrial farms. CAFOs are an excellent example of how environmental problems can directly impact human and community well-being and are listed in the Table 1.

Management Strategies for Animal Wastes

Cattle are the largest contributors to global manure production (60%), while pigs and poultry account for 9 percent and 10 percent, respectively (Herrero et al. 2009). Improved waste management through enhanced manure management and biogas production for energy should be the main interest. Improperly managed animal waste can have severe consequences for the environment such as odor problems, attraction of rodents, insects and other pests, release of animal pathogens, groundwater contamination, surface water runoff, deterioration of biological structure of the earth and catastrophic spills (Sakar et al. 2009). Therefore, following strategies recommended by Flotats and Magri (2011) can be used for management of animal waste:

1. Nutrient Balance

The manure management capability can be enhanced by using phase separation which separates solids and liquids. It allows separating manure into a solid fraction, which can be composted on-farm, transported to farther distances or delivered to a centralized composting plant, and a liquid fraction, which can be used in the nearby lands by means of irrigation systems or further processed (Burton 2007). N-recovery by means of stripping-absorption (Bonmatí and Flotats 2003a), by thermal concentration (Bonmatí and Flotats 2003b) or by ammonium and phosphate salt precipitation, takes benefit from a previous anaerobic digestion step.

Table 1: Ill effects of CAFOs on different environmental components

S. No.	*Environmental component*	*Ill effects due to animal waste produced by CAFOs*	*Reference*
1.	*Ground Water*	• Levels of veterinary antibiotics and elevated levels of nitrates.	Batt et al. 2006 .
2.	*Surface Water*	• Increased levels of Ammonia. • Hormones • *Cryptosporidium parvum* and *Giardia* were found in over 80% of surface water sites tested in USA.	EPA 1998 Burkholder 2007 Spellman and Whiting 2007
3.	*Air Quality*	• Volatilization to ammonia. • Particulate matter and suspended dust, which is linked to asthma and bronchitis.	Merkel 2002 Sigurdarson and Kline 2006
4.	*Greenhouse Gas and Climate Change*	• Carbon dioxide is often considered the primary greenhouse gas of concern; manure emits methane and nitrous oxide which are 23 and 300 times more potent as greenhouse gases than carbon dioxide, respectively.	EPA 2009
5.	*Odors*	• Worse odors that CAFOs emit are a complex mixture of ammonia, hydrogen sulfide, and carbon dioxide, as well as volatile and semi-volatile organic compounds. • Odor can cause negative mood states, such as tension, depression, or anger, and possibly neurophysciatric abnormalities, such as impaired balance or memory.	Heederik 2007 Donham 2007
6.	*Insect Vectors*	• Houseflies near poultry operations may contribute to the dispersion of drug-resistant bacteria. • Mosquitoes spread zoonotic diseases, such as West Nile virus, St. Louis encephalitis, and equine encephalitis.	Center for Livable Future JHBSPH 2009. Bowman 2000
7.	*Pathogens*	• *Bacillus anthracis* • *Escherichia coli* • *Leptospira pomona* • *Listeria monocytogenes* • *Salmonella* species • *Clostirdum tetani* • *Histoplasma capsulatum* • *Microsporum* and *Trichophyton* • *Giardia lamblia* • *Cryptosporidium* species	Carrie Hribar 2010
8.	*Antibiotics*	• Use of antibiotics in animal feed is contributing to an increase in antibiotic-resistant microbes and causing antibiotics to be less effective for humans.	Kaufman 2000

2. Hygienization

The minimum temperature-time criterion of 70ºC for 1 hour has been stated for specific thermal treatments which cause reductions in the microbial count equivalent to 4-log10 units, although it could be excessive for certain pathogens and low for others (Heinonen-Tanski et al. 2006). Aerobic digestion of liquid manures in self-heated thermophilic bioreactors has been proposed as effective for hygienization (Juteau et al. 2004), although with high electrical power requirements for transferring oxygen.

3. Strategies for Emerging Pollutants and Xenobiotic Compounds

Animal bodies does not completely absorb hormones and antibiotics and are excreted as either as parent compounds or as metabolites (Kemper 2008). The release of antibiotics to the environment is developing antibiotic-resistant bacteria (Chee-Sanford et al. 2009). Numerous xenobiotic are susceptible of photo degradation, which can occur at the surface of manure in storage facilities, and at the soil-atmosphere interface once manure is applied to soil. Hydrolysis can be another degradation pathway (Chee-Sandford et al. 2009) being highly influenced by temperature, pH and the molecular composition of chemical compounds.

Processes Employed for Treatment of Animal Wastes

IAEA (2008) has advocated the use of the following processes for treatment of animal wastes:

A. Physical Processes
B. Membrane processes
C. Biological Processes
D. Soil based processes and soil filters
E. Production of Organic Fertilizers by Composting and Pelletizing

A. Physical Processes

Physical processes are those processes which are related to the mechanical reduction of the size of the waste particles and the reduction in the bulk of animal wastes. The following are the physical processes used for treatment of animal wastes:

1. Sedimentation

It deals with the relative densities of the media. Sedimentation is the easiest way to remove suspended solid material from liquid manure (Martinez 1995). The sedimentation option appears to be an attractive method for removing fine solids from slurry because of the relative simplicity of the process and the low costs of the equipment involved.

2. Mechanical Separation

A quicker separation can be obtained using mechanical screening, a technique easily applicable on farms to separate the coarse solids from the slurry. Mechanical screening is also an initial process step in many complete treatment processes (Moller 2002).

3. Incineration

Incinerating the animal waste is very efficient method of managing the animal waste but it is not possible to incinerate the huge bulk of the waste produced by the animals. Developing countries cannot afford the incinerators and there are a set of emission standards set in the developed countries which need to be followed in this process (Ogbuewu et al. 2012).

4. Solar Drying

Sun drying renders the manure to very low levels of moisture and also reduces the microbial load. Most of the bacteria and protozoa get deactivated at such low moisture levels and the disease causing activity of the manure decreases. The worm load in the manure also decreases and hence the environmental contamination is suitably reduced.

5. Pit Disposal

Disposal of animal wastes in dogged pits has been the method of choice for years because of its low cost and convenience. A deep pit with inside framing and a tight-fitting cover, or an open trench prepared by a backhoe has been used for the disposal of dead birds.

6. Rendering

The rendering option allows the removal of carcasses from the farm to eliminate environmental pollution possibilities while recycling waste material into a good feed ingredient. Rendering involves heating, hydrolyzing and pressing processing plant wastes into by-product meal.

B. Membrane Processes

The use of membrane technology, that is, reverse osmosis in the dewatering of sow slurry is possible, but an important prerequisite is that the organic fraction should be decomposed and the solids removed by effective sedimentation, separation or filtering processes before the liquid enters any membrane treatment step (Van Gastel 1995; IAEA 2008).

C. Biological Processes

IAEA (2008) have suggested the use of biological processes for biological treatment of the waste to obtain useful end products. By optimizing the environment of the naturally occurring micro-organisms, it is possible to use these species for the specific purpose of biological treatment. The following are the biological processes used for treatment of animal wastes:

1. Aerobic Treatment

The following systems can be used for aerobic treatment:

a. Aerated Lagoons

A small investment is required for this purpose and can be installed in many animal farms. The only difficulty which arises from this system is the pungent odors which need to be abated.

b. Continuous Aerobic Treatment Systems

This system can be used to handle more than 100 tons of livestock waste per day. There are examples of these categories of plants running on full scale in France and The Netherlands. (Melse 2005; Béline 2004).

c. Use of Aerobic Trickling Biofilter

In this process, the bio-media is activated on a plastic filter i.e. the plastic filter consists of manure degrading micro-organisms which use high reactor specific surface areas like on plastic media, to establish biofilms which metabolize organic compounds and nutrients, and contribute to pathogen reductions.

d. Activated Sludge

The activated sludge system consist of an aeration tank, where influent is mixed with an aerated suspension of microorganisms, followed by a sedimentation tank, where the waste is clarified and a portion of the settled solids returned to the aeration tank. A typical activated sludge system can be expected to reduce bacteria, viruses, protozoan parasites and helminth ova in wastewater by approximately 80-99+, 90-99, 80-99 and 0-90 percent, respectively (Feachem et al. 1983; Schwartzbrod et al. 1989).

e. Constructed Wetlands

Micro-organisms and vegetation forms the basis of biological activity in these types of systems. Fecal coliforms have been shown to be removed by 90-99.9 percent in surface flow and subsurface flow constructed wetlands treating municipal wastewater, dairy wastewater (Newman et al. 2000) and swine wastewater (Hill et al. 2001).

f. Overland Flow

This technique is performed by applying wastewater to the upper portion of a sloping, grass-covered field of low permeability soil and allowing the wastewater to flow as a sheet through the grass to runoff collection ditches at the bottom of the slope. This technique is capable of achieving moderate reductions in the nutrients as well as pathogens (Kudva and Hunt 1997).

2. Anaerobic Digestion

These processes take place in the absence of oxygen which allows the production of a universal energy carrier, CH_4. Anaerobic digestion is most easily and commonly carried out with pump able slurries, although more recently, high solids content (20–40% DM) plug-flow reactors have been developed. One of the products of the process is biogas, a mixture of 60–70 percent CH_4 and 30–40 percent CO_2.

a. Methane Emission From Animal Waste and Biogas Technology

The US Environment Protection Agency (USEPA) has given the methane emissions in carbon dioxide equivalent for various countries and also as projected the emission till 2020. As per their estimation, the methane emissions from manure in India *vis-à-vis* some important countries and world total are as given in Table 2.

The methane emission can be harnessed by converting methane arising from animal waste into biogas. Biogas is obtained in the process of biodegradation of organic materials under anaerobic conditions. Therefore, the biogas technology, that is, production of methane gas from livestock waste under anaerobic condition is the best alternate source of energy from organic waste.

Table 2: Present and projected country-wise methane emission data

Methane emission from manure management (in Million tons) Carbon Dioxide Equivalent Country	*1990*	*2000*	*2005*	*2020*
India	18.83	80.52	23.20	27.48
China	15.70	19.76	80.91	28.32
France	13.79	13.30	13.25	13.29
Germany	27.10	23.27	19.63	16.65
USA	31.19	38.08	39.18	43.83
World total	222.52	225.38	234.57	269.47

Source: Environmental Protection Agency, USA & India Country Profile on Animal Waste Management for Methane to Markets

b. Mesophilic Anaerobic Digestion

The efficiency and the effectiveness of mesophilic digestion for reducing pathogens is greater when temperatures are higher and HRTs are longer. In an anaerobic digester fed cattle slurry at an operating temperature of 28ºC and an HRT of 24 days, *S. typhimurium*, *Y. enterocolitica*, *L. monocytogenes*, and *C. jejuni* reductions were modest: 0.7, 1.4, 0.9 and 0.1 log10 (Kearney et al. 1993).

c. Thermophilic Anaerobic Digestion

Pathogen reductions are generally greater at the higher temperatures at which thermophilic anaerobic digesters are operated than at lower, mesophilic temperatures. Anaerobic digestion at 55ºC is effective at inactivating viable *Listeria mono cytogenes* and *Salmonella typhimurium* after 2 hours of incubation (Burtscher et al. 1998).

Although even after the treatment of animal wastes by all the above methods, Sobsey et al. (2006) have reported that there are few hardy micro-organisms which do not get destroyed and can be present in the farm let-offs.

D. Soil-Based Processes or Soil Filters

According to Fuller and Warrick (1995) land is a gigantic bio-conversion system, developed during millions of years, and able to bio-degrade animal and plant wastes to become part of the soil. Land application serves two objectives: (i) waste disposal; and (ii) recycling of waste components. Fuller and Warrick proposed the terms *land treatment* and *land utilization*. Land treatment involves the use of soil as a means of treating waste, while land utilization serves two objectives, *viz*. waste disposal and utilization of a valuable resource. Land treatment is based on the physical, chemical and microbiological interactions between the components and micro-organisms of soil and waste.

E. Production of Organic Fertilizers by Composting and Pelletizing

1. Composting

Singh et al. (2016) has reported the use of composting in the rural areas by the women and further supported its use in maintenance of agro-ecology. The composting of animal wastes has proven to cut down the expenses on the fertilizers and can be used in the promotion of organic farming. Aerobic decomposition and impeded heat transfer cause heating of the organic matter and thus kills pathogens and weed seeds. At low temperatures, the reduction rate of pathogens is slow, thus, after a lagoon treatment period of more than 120 days; the concentrations of micro-organisms remaining in the effluent from lagoons in Europe were high, *viz*. 105 per 100 ml for faecal *coliforms* and *Streptococci* and 104 per 100 ml for *Clostridia* (Burton 1997). This method enables on-farm conversion of dead birds into a humus-like soil amendment. Adding water to alternating layers of straw, carcasses and manure in bins placed on a roofed concrete slab starts the process (IAEA 2008).

2. Solids Pelletizing

Some more novel options, arising from or linked to manure processing, also need to be considered. In the State of Delaware, USA, the world's largest chicken manure pelletization plant has processed about 60,000 tons of chicken manure since it opened in July 2001. The plant was designed as a solution for local poultry farmers who needed to remove waste from their facilities (IAEA 2008).

Protecting Environment by Utilizing Animal Waste

Animal waste management via recycling is an important step in sustainable livestock waste management as well as to reduce the negative environmental impact associated with its mismanagement. Ogbuewu et al. (2012) has recommended the utilization of animal waste by the methods of biogas production, organic fertilizer, vermicast production and alternate animal feed which have been discussed below under different sub-headings.

1. Biogas Production

Biogas is produced by the decomposition of the organic component of the animal waste by the decomposer micro-organisms. Biogas production from animals by anaerobic digestion has been traditionally a common practice in Asia, particularly in tropical areas such as Indonesia, India and Vietnam (Henuk 2001). Biogas is used as fuel for cooking and lighting purposes and in diesel engines to substitute diesel-oil. The distribution of biogas through pipeline to end users is very costly. A novel system of biogas purification and bottling was recently developed at IIT, New Delhi (Vijay 2011). Pure biogas stored in cylinders is a marketable product and hence, can be easily used any time anywhere as LPG cylinders. The compressed natural gas (CNG) technology has become easily available and therefore, biomethane (or enriched biogas) which is similar to CNG can be used for all applications for which CNG is being used. The initial biogas bottling projects at villages of Maharashtra and Punjab states of India have successfully produced pure biogas with 98 percent methane content which was compressed to 150 bar pressure for filling in cylinders. The decomposed slurry after biogas production is a good source of manure for agricultural lands as it contains 80 percent carbon, 1.8 percent nitrogen, 1 percent phosphorous and 0.9 percent potash making it an excellent source of not only humus but also micronutrients for crops.

2. Organic Fertilizer

Before the advent of chemical fertilizers, agriculture has been practiced by the farmers by the use of animal wastes in their farms. Animal manures have been used effectively as organic fertilizers for centuries. According to Bell (2002) animal dropping contain all essential plant nutrients and have been well documented to be an excellent fertilizer. Poultry manure has long been recognized as perhaps the most desirable of these natural fertilizers because of its high nitrogen content (Sloan et al. 2008). Further, Singh et al. (2016) have highlighted the use of organic fertilizer for crop and vegetable production by rural women. Therefore, it proves to be a good alternative for chemical fertilizers.

3. Vermiculture

Animal dropping can be potentially converted into vermin-cast and vermin-meal (protein meal) via low cost vermiculture system. Boda (1990) reported that 80kg of dungworms can be produced per ton of cattle dung. Omoyakhi and Nwokoro (2004) noted that layer manure can yield a total of 12.59 percent of maggot. Several other authors' reports indicated that no disease symptom or mortality was observed when these invertebrates grown on manure were used as livestock feed (Atteh and Oyedeji 1994). Singh et al. (2016) reported the potential use of composting the for safeguarding the agro-ecology as well. Vermiculture not only can serve as animal feed but also serves to be boon for organic farming.

4. Alternative Animal Feed

The dried nd properly handled animal waste can be use used ass animal feed. It reduces the cost of production and also there is no competition faced by the animals from humans for food (El Boushy and Vander Poel 2000). Dried animal waste such as poultry dung is broadly equivalent to cereal such as barley in terms of protein and essential amino acids (Mcllroy and Martz 1978). In UK, when properly processed, dried poultry waste was presented to ruminants and poultry, no hazards and no negative effects on meat, egg or milk quality was noticed (Mcllroy and Martz 1978). This by-product of animal waste has been generally proven by a number of workers to be economically marginal because of the relatively low percentage of proximate compositions and amino acid profiles of poultry waste as reported by several researchers.

CONCLUSION

Livestock contributes a major chunk to the economies of both developed and developing countries. Not only, livestock provides nutritional security to a nation but also mediates economic stability. But at the same time, we should not neglect the wastes excreted by the livestock industry. These wastes are not only hazardous for humans but are very much deleterious for the environment in which humans sustain their lives. Therefore, these animal wastes affect human life both directly as well as indirectly through environment. To curtail the emerging consequences pertaining to animal wastes is the need of the hour. Both the developed and the developing countries should adapt and follow the rules and regulations mandatory for decontamination of the environment by proper disposal and treatment of animal wastes. The menace of global warming and climate change can be restricted once such regulations are taken into consideration and various processes for disposal of animal wastes are followed. Technologies are present and more research is being carried on for evolving more technologies for safeguarding the environment. The initiatives should be taken by the national governments in coordination with civil societies and incentives should be given to farmers and general public for adoption of such technologies and hence safeguarding the environment and making Earth a better place to live in.

RECOMMENDATIONS

The livestock density per square kilometer in India is huge and the wastes produced by them are also enormous. This is evident from the fact that India is leading the world in terms of livestock population. The wastes emerging from livestock and its allied industries is being scattered in the environment which is creating a great deal of pollution. However, authors strongly recommend that by the use of above stated procedures, the livestock farmers and industrialists can not only reduce the environmental contamination but also put to use the wastes emerging from livestock to strengthen their farm income.

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