THE SCIENCE WORLD
A Monthly e Magazine
ISSN:2583-2212
Popular Article
March, 2026 Vol.6(3), 845-856

Pollutants from Intensive Pig Farms and Their Impact on the Environment

Divyanshu Sharma, Anupam Soni, Harsimar Preet Kour*, Bhupender and Kanta Godara
Livestock Production Management, NDRI Karnal, Haryana
*harsimar0303@gmail.com
doi.org/10.5281/ScienceWorld.19554136

Introduction

Intensive pig farming, also known as industrial pig farming or factory pig farming, is a method of raising pigs in high-density, confined and controlled environments to maximize production efficiency, meat yield and profit. This system is widely practiced in many parts of the world to meet growing demand for pork, but it comes with significant environmental, ethical and public health concerns. Intensive non-bedding pig farming leads to the formation of large quantities of waste in the form of slurry which is a liquid heterogeneous mixture of animal excrement (urine to faeces ratio is approximately 60 to 40 %), undigested food residues and water used for hygienic and cleaning purposes in livestock buildings.

Pig farms are a growing environmental concern for pollution due to large volume of waste, toxic gases and chemicals emitted and risks to water, air and soil quality. This is particularly problematic in intensive pig farming systems, where thousands of animals are kept in confined spaces, generating concentrated pollution in a small area. Indoor animal houses can be rich in harmful contaminants that could threaten animal safety, cause discomfort and distress and also reducing their welfare.

Pig slurry may contribute to climate change, being the source of methane, carbon dioxide and nitrous oxide emissions. These gases cause the greenhouse effect by trapping the infrared radiation and its subsequent emission as reverse thermal radiation, which leads to the increase of temperature on the Earth surface. Rural areas also struggle with specific challenges concerning air quality. In areas where we have to deal with intensive non-bedding pig farming atmospheric pollution with odorants emitted from fields sprayed with pig slurry, from slurry tanks and livestock buildings is present. Malodorous compounds cause the formation of unpleasant and onerous odours which are reason for inconvenience for local communities living in areas adjacent to the farms. They can also trigger a large number of diseases such as ailments of the respiratory system

(rhinitis, bronchitis, pneumonia, asthma), skin infections, allergies, headaches, migraines or states of nervous irritation.

Types of Pollutants from Pig Farming

Pig farming, especially intensive and industrial-scale operations, generates a wide range of pollutants that impact air, water and soil. These pollutants arise mainly from:

- Animal manure and urine
- Feed residues
- Washing water
- Slaughterhouse waste
- Chemical additives (e.g., antibiotics, heavy metals)

A) Nutrient Pollutants (Nitrogen and Phosphorus)

Pig farming, especially in large-scale or intensive operations, can be a significant source of nutrient pollution. The main nutrient pollutants are nitrogen (N) and phosphorus (P), which originate primarily from pig manure and urine. When these nutrients enter the environment in excess, they can cause serious ecological problems such as eutrophication of water bodies. When applied to land or overflowing during rains, they run off into surface waters and leach into groundwater.

B) Gaseous Pollutants (Air pollution & Greenhouse gases)

Pork is the most widely consumed meat product in the world and pig production is the second contributor of GHG emissions from livestock sector. Overall, GHG emissions from pig houses are estimated to 448.4 kg CO_2 equivalent per slaughter pig produced or 4.87 kg CO_2 equivalent per kg carcass. The fattening period accounts for more than 70% of total emissions, while the gestation, lactation and weaning periods each contribute to about 10% of total emissions (Philippe and Nicks, 2015).

i. Ammonia (NH_3) Produced from the decomposition of urea in urine and its emissions are one of the main factors increasing soil acidification. Soil acidification leads to the dissolution and leaching of nutrients, macro and micro elements and toxic heavy metals. NH_3 concentrations in swine buildings show large variations and are related to a number of factors, including animal age, activity and density, outdoor temperature, ventilation control (Rodriguez, 2020). NH_3 is not only an odorant but also the main factor determining an increase in the acidification of atmosphere and soil. This gas may contribute to a significant decline in animal productivity as well as animals' death.

ii. Methane (CH_4) is a dangerous greenhouse gas with global warming potential 21 times greater than that of carbon dioxide and it is responsible for 18% of the global greenhouse effect (Mohajan, 2012). CH_4 released from pig slurry is produced by an aerobic decomposition of organic matter by bacteria. This process takes place mainly (65–75%)

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 30/03/2026

during storage of pig slurry, but may also occur after its application in fields. The second important source of methane (10–15%) is the anaerobic breakdown of animal faeces.

iii. Nitrous oxide (N_2O) from manure and soils. Nitrogen oxides can react with water vapour in the atmosphere to form nitric acid, which falls to the surface of the earth as precipitation, causing acidification of the environment and eutrophication of aquatic ecosystems. N_2O also contributes to the destruction of the ozone shield. N_2O emission from the stored slurry is negligible (emissions are chiefly caused by crust formation at the surface of the slurry) and comes mainly from the soil fertilized with the slurry since this gas is one of the intermediates of denitrification process (formation of nitrogen gas from nitrate reduction).

iv. Carbon dioxide is a key greenhouse gas; its global warming potential (GHG) by definition is 1 (Marszałek *et al*., 2018). CO_2 emitted from pig slurry is generated during putrefaction and fermentation processes (aerobic and anaerobic decomposition of organic substances) taking place in pig slurry, as well as during hydrolysis of urea. A source of CO_2 in piggeries, apart from slurry, are also animal respiration processes. Its permissible concentration in livestock buildings amounts to 3000 ppm. Elevated concentration of CO_2 reduces the frequency and increases the depth of respiration in animals, while long-lasting and excessive concentration of CO_2 leads to metabolic disorders or even acidosis.

C) Odorous Compounds

Pig farms are known for their strong odour, which affects local communities.

Common odorous gases:

- **Hydrogen sulphide (H_2S)** – Hydrogen sulphide (H_2S) is a colourless, toxic and flammable gas with a characteristic rotten egg smell. It is a common pollutant in intensive pig farming operations and poses health risks to animals, workers and nearby communities. Low concentrations of H_2S cause irritation to eyes, nose, throat and respiratory tract but high concentrations (>100 ppm) can cause rapid unconsciousness, respiratory failure and death.
- **Volatile fatty acids** – An inseparable element of raising and breeding farm animals is emissions of volatile organic compounds (VOCs), including alcohols, aldehydes and aromatic and aliphatic hydrocarbons, as well as typically odorous pollutants – phenols, indoles, amines, fatty acids and organosulphur compounds (Korzeniowska *et al*., 2018). In livestock buildings, the main sources of VOC emissions are feed, litter, and the animals themselves. An important factor in the transmission of these pollutants is organic dust. As the dust concentration in buildings increases, the amount of ammonia and odorous compounds and the number of microorganisms in the air increases as well.
- **Indoles, skatoles** – Indoles and skatoles are volatile organic compounds (VOCs) that are significant contributors to the characteristic odor of pig manure and pig farming

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 30/03/2026

operations. Both are produced during the anaerobic microbial breakdown of tryptophan in the pig's gut and in manure storage.

D) Heavy Metals, Antibiotic Residues, Hormones, Pathogens

- Heavy metals like copper (Cu) and zinc (Zn) are added to pig feed to promote growth or prevent disease. Soil near farms receiving manure may accumulate heavy metals. Heavy metals like cadmium, lead, arsenic, zinc and copper can bioaccumulate in the food chain.
- Use of antibiotics and growth promoters: residues may enter environment, promoting antimicrobial resistance. Hormones similarly may affect ecosystems.
- Pig manure contains pathogens such as bacteria (Salmonella, E. coli), viruses (Porcine reproductive and respiratory syndrome virus) and parasites. They spread zoonotic diseases to humans and other animals, contamination of water sources and public health risks due to direct contact or consumption of contaminated products.

E) Solid Waste & Wastewater

- Intensive pig farming has solid waste from solid manure (undigested feed, bedding, hair etc), Slaughterhouse waste (bones, offal, blood) and Feed spillage. Wastewater from cleaning barns, leaks, run-off, leaching; slurry storage lagoons; sometimes direct discharge.

Pathways of Pollutant Release & Environmental Media Affected

- **Soil pathways**: direct application of manure, slurry, runoff, infiltration, accumulation.
- **Water pathways**: surface runoff during rains, leaching through soil to groundwater, overflow of storage, leaks.
- **Air pathways**: volatilisation of ammonia, emission of gases (methane, N_2O, CO_2), odorous compounds, dust, particulate matter.

Environmental Impacts of Pollutants from Intensive Pig Farming

Pig farming, especially intensive operations, emits a variety of pollutants—nutrients (nitrogen, phosphorus), pathogens, greenhouse gases, ammonia, heavy metals, odours, etc. These have significant impacts on ecosystems, human health, soil, water, air and climate. Below are the main impact categories.

A. Water Pollution (Surface Water & Groundwater)

- **Nutrient enrichment (Eutrophication):** Manure and slurry from pig farms contain high levels of nitrogen (N) and phosphorus (P). When runoff or leaching carries these nutrients into rivers, lakes, wetlands, or reservoirs, it leads to overgrowth of algae (algal blooms). When these blooms die off, decomposition consumes dissolved oxygen → leads to hypoxia or anoxia (oxygen depletion), which can kill fish and other aquatic life.
- **Contamination with pathogens & pharmaceuticals:** Wastewater may carry bacteria (e.g. *E. coli*, *Salmonella*), viruses, parasites, antibiotic residues, hormones. These can enter

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 30/03/2026

drinking water sources or irrigation water. Human exposure is then possible via consumption of contaminated water or food.

- **Groundwater risks:** Nutrients and pathogens can leach through soil into shallow wells or aquifers. In places with porous soils or insufficient waste treatment, groundwater may become contaminated with nitrates or pathogens, making water unsafe. In many studies, shallow well water near farms had poorer quality or risk of contamination.

B. Soil Degradation and Alteration

- **Heavy metals, minerals accumulation:** Through repeated application of manure (especially if feed contains supplements like copper, zinc), heavy metals accumulate in soil. Over time, this can degrade soil health (affect microbial activity, soil structure), and can lead to uptake by plants (entering the food chain).
- **Salinization or Altered pH:** Excess manure can alter soil pH, sometimes there is build-up of salts or ammonium compounds, which may affect plant growth.
- **Over-application/Nutrient imbalance:** When manure application exceeds what crops need, nutrients (especially phosphorus) accumulate, which increases the risk of runoff in future rain events.
- **Loss of soil structure/Compaction:** High traffic (heavy equipment) or poorly managed slurry application can compact soils, reducing infiltration, increasing surface runoff, reducing root penetration.

C. Air Pollution and Odour

- **Ammonia (NH_3) emissions:** Decomposition of urine (urea) in slurry/manure produces ammonia. Ammonia contributes to local air pollution and can travel, deposit elsewhere, contributing to acid rain, eutrophication of downwind ecosystems (e.g. lichens, mosses). Ammonia also reacts in the atmosphere to form fine particulate matter ($PM_{2.5}$), which is harmful for human respiratory health.
- **Greenhouse gas emissions (GHGs):**

  Pig farming emits:

  1. Methane (CH_4) from anaerobic decomposition in manure storage, pits or lagoons.
  2. Nitrous Oxide (N_2O) from nitrification/denitrification processes in manure and in soils to which manure is applied.
  3. Carbon dioxide (CO_2) from feed production, energy use on farm, transport, processing.

  These gases contribute to climate change (global warming, altered weather patterns).
- **Particulate matter & Bioaerosols:**

  Dust, suspended particles (TSP, PM_{10}), volatile organic compounds, microorganisms (bioaerosols) are released in pig sheds, during manure handling and when fields are

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 30/03/2026

sprayed with waste. These can cause irritation of eyes/nose/respiratory tract for workers and nearby residents.

- **Odour & local air discomfort:**
  Odours from hydrogen sulphide (H_2S), ammonia, volatile fatty acids etc. cause nuisance, reduce quality of life, can affect mental well-being.

D. Human Health Impacts

- Exposure to contaminated water can lead to gastrointestinal diseases, infections, sometimes long-term exposure to heavy metals can lead to organ damage.
- Air exposure: respiratory problems, asthma, irritation, possibly cardiovascular effects from $PM_{2.5}$, Ammonia and hydrogen sulphide are irritants.
- Spread of antibiotic resistance: residues in waste select for antibiotic-resistant bacteria, which can spread to soil, water, possibly enter human microbiome via food/water.
- Occupational hazards: workers in pig farms are exposed to high ammonia, dust, pathogens etc, leading to higher risks of respiratory illnesses, skin/eye irritation.
- Also, social/psychological: odour nuisance, reduction in property values, tension in communities.

E. Biodiversity and Ecosystem Impacts

Nutrient loading → eutrophication of water bodies, which can alter species composition, reduce oxygen, kill fish or amphibians. Ammonia deposition onto ecosystems (e.g. forests, wetlands) can damage sensitive vegetation, alter species composition (Favor nitrophilous species), reduce lichen, moss diversity. Loss of aquatic habitat health, possibility of toxic algal blooms. Impacts from land use change: feed cultivation (soy, maize) may drive deforestation, habitat loss, soil erosion, biodiversity loss. This is an indirect impact of pig farming. Relied heavily in many pig-system environmental life cycle analyses.

F. Contribution to Climate Change

The GHGs from pig farming contribute to global warming: methane & nitrous oxide are high-global warming potential gases. Emissions come not only from waste but from feed production (fertilizers, land use change), energy use, transport. For example, a study "Environmental Impact Assessment of Sustainable Pig Farm via Management of Nutrient and Co-Product Flows" found that feed production is estimated around 60% of emissions in pig supply chains globally; manure storage/processing contributes about 27%. These emissions exacerbate climate change effects: increased droughts, floods, heatwaves, which in turn can worsen pig farm pollution (e.g. runoff during heavy rain, drought reducing buffering capacity of ecosystems).

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 30/03/2026

G. Socio-Environmental & Economic Impacts

Communities near pig farms often bear burdens (air, water pollution, odour) while receiving little benefit; environmental injustice. Lower property values, reduced recreational or aesthetic value of landscapes. Costs to governments or society: treating polluted water, remediating soils, health care costs due to exposure etc. Potential conflicts: local resistance, NGO activism, legal cases. Farming costs may increase if pollution leads to regulatory fines or remediation requirements.

Global Case Studies:

I. **Reunion Island (France) – Soil and groundwater pollution from pig effluent**
   - Researchers studied how pig effluent (slurry/manure) used on pastures contributes to **nitrate contamination** of soils and groundwater. They used stable isotopes (^15N, ^18O) to trace nitrate sources.
   - Key findings: Pig effluent was a major source of nitrates among several agricultural sources; over time, nitrate leaching into groundwater increased. Implication is risk to drinking water quality and cumulative pollution from repeated applications.

II. **Spain / Catalonia – Manure export to crop fields as pollution mitigation**
   - Case: In Catalonia, researchers looked at transport and use of livestock manure (including from pig farms) to nearby crop fields. The idea is to reduce pollution by ensuring manure nutrients are used by crops instead of accumulating or running off.
   - Findings: Coordinated logistics and optimal algorithms reduce nitrogen pollution and distance costs; decentralized cooperative methods also helped. Suggests managed manure movement can mitigate environmental harm.

III. **Full-scale slurry management (pig farms) – nutrient recovery**
   - Case: A study using membrane separation to treat pig slurry. It recovers concentrates of N (nitrogen) and P (phosphorus), reduces waste storage volume, produces fertilizer amendments.
   - Impacts: Reduced nutrient pressure on environment (less N & P loss), lower requirement for synthetic fertilizers, though energy demand matters. Useful best-practice example of technological mitigation.

IV. **Microalgae-bacteria consortium treatment of pig-farm wastewater**

A recent study evaluated treatment of wastewater (pig farm) using microalgae + bacteria to remove nitrogen, phosphorus, organic matter and heavy metals.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 30/03/2026

Results: Good removal efficiencies; demonstrates lower-cost, biological treatment potential, especially in places where large mechanical/chemical treatments aren't feasible.

V. **Nitrogen flow and circular economy with pig manure, biochar, ash**

Experiment combining pig manure digestate (from anaerobic digestion) with biochar and ash, applied in soils (both neutral and acidic), to see effects on nitrogen use efficiency, phosphorus, potassium, biomass yield.

Implication: Better soil fertility with reduced environmental loss; promotes recycling of waste and lower environmental pollution.

6. India / Haryana Specific Situation

1. **Assessment of microclimate and gaseous pollutants in pig & dairy sheds (Tamil Nadu, India)**
   - In an organized farm in Tamil Nadu, a study measured ammonia (NH_3), CO_2, CH_4 in pig sheds and dairy sheds across different seasons.
   - Findings: Levels of gaseous pollutants varied by time of day and type of shed; though within recommended thresholds, such emissions are still notable contributors to air pollution and occupational exposure. Useful baseline for comparing against less-regulated farms.
2. **Pig farming in haryana: Prospects and Retrospect's**
   - This study looks more at socio-economic, management, housing, mortality etc., but it also notes insanitary conditions, poor housing standards, over-crowding, lack of proper orientation of sheds, spacing problems. These conditions are likely to contribute to environmental pollution (manure runoff, poor ventilation leading to gaseous emissions) even though the paper does not deeply quantify pollution.
3. **KVASU Pig farm effluent treatment plant, Kerala**
   - Kerala Veterinary and Animal Sciences University developed an effluent treatment plant for pig farm wastewater (Centre for Pig Production and Research, Mannuthy), capable of handling 75,000-80,000 litres/day.
   - This helps reduce direct discharge of pig wastewater into surroundings, mitigate water pollution, reuse some treated water (for fodder plots etc.). A good example of mitigation in Indian context.
4. **"Pig Farm Upsets Villagers" – Jalandhar, Punjab, India**
   - Local case: A pig farm in Birring village near Jalandhar (Punjab) is causing complaints from local residents about pig faeces waste spreading, contaminating air & water with toxic waste particles, odors etc.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 30/03/2026

- While not a scientific quantified study, this case illustrates community-level perception & environmental impact of unmanaged pig waste.

Regulatory Framework & Mitigation Technologies

Regulations & Policies

Currently, livestock farms must meet quality and economic requirements, and at the same time they are required by Polish and European law to take into account the state of and impact on the natural environment. The intensification of animal production ensures greater profits, but also increase the level of pollutants in the natural environment. For this reason, livestock farms raising or breeding over 210 LSU are categorized as enterprises that can significantly affect the environment. Their activity is guided by the Best Available Techniques Reference Document (BREF), which contains requirements and recommendations for intensive pig and poultry farming. The document requires the use of housing systems and techniques that entail the lowest possible emissions. The BREF was introduced by European Council Directive 96/61/EC of 1996 (IPPC Directive – Integrated Pollution Prevention and Control) (IPPC, 2008). The related document (the IPPC Directive) is the Commission Implementing Decision (EU) 2017/302 of 15 February 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the intensive rearing of poultry or pigs.

- Emission standards for ammonia, water discharge permits, nutrient management.
- Zoning rules (restricting pig farms near sensitive ecosystems or water bodies).
- China has used emission trading mechanisms for pig farming non-point source pollution in some provinces (e.g. Zhejiang).

Mitigation Technologies & Best Practices:

- ✓ An important element of prevention of the spread of pollutants from waste storage sites (both solid and liquid manure) is the use of physical barriers. Materials used to cover the top layer of slurry in the tank.
- ✓ Treatment of wastewater before discharge, remove solids before settling ponds or before discharge or reuse.
- ✓ Solid-liquid separation, composting, frequent removal, aerobic treatment, or biofiltration to reduce VOC emissions.
- ✓ Biofilters, scrubbers, adequate barn ventilation to disperse odorous gases, waste-air cleaning systems.
- ✓ Land application guidelines: matching manure application with crop needs to avoid overloading.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 30/03/2026

- ✓ Reducing the protein content in feed in combination with supplementation with essential amino acids (methionine, lysine, threonine and tryptophan) can significantly reduce the amount of nitrogen excreted without causing production losses.
- ✓ The use of 0.2% symbiotics containing bacteria and yeast significantly reduces the amount of ammonia and hydrogen sulphide in the faeces.

Challenges in Mitigation & Conflicts:

- Economic cost: installing digesters, treatment plants etc. is expensive.
- Scale: many pig farms are small/medium which may lack capital/resources/technical know-how.
- Monitoring & enforcement: regulatory agencies may lack capacity.
- Social resistance: odour, stigma; local communities may oppose farms; farmers may resist change.

Trade-offs: e.g. storing manure longer reduces odour but may increase methane etc.

Future Directions & Sustainable Alternatives:

Integrated livestock systems; circular models (using manure for biogas). Precision farming: sensors, modelling to optimize feed and manure management. Policy incentives: subsidies for cleaner technology, penalties for pollution, market mechanisms (e.g. emission trading). Research on reducing antibiotic use, alternative feed additives, more efficient housing. Local studies in India/Haryana to generate data.

Conclusions:

Summarize the main pollutants, environmental and health impacts. Emphasize that intensive pig farming has significant negative externalities. Excessive and continuous applications of animal manure to agricultural soils might cause heavy metals to pose a potentially high-risk level in the soil–rice system. Argue for stronger regulation, technological mitigation and more research especially in regions like Haryana/India.

Effective reduction of greenhouse gas emissions from pig production can be achieved by creating a suitable microclimate in the piggery (hygienic and technological methods), as well as by implementing a suitable feeding strategy.

References

Aneja *et al*. (2008), "Emission of ammonia, hydrogen sulfide, and volatile organic compounds from animal feeding operations," Environmental Monitoring and Assessment, 140(1-3), 31–44.

Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs. Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control). Luxembourg: Publications Office of the European Union; 2017. DOI: 10.2760/020485.

Blanes-Vidal V., Hansen M.N., Pedersen S., Rom H.B. (2008). Emissions of ammonia, methane and nitrous oxide from pig houses and slurry: Effects of rooting material, animal activity and ventilation flow. *Agric. Ecosyst. Environ*., 124: 237–244.

Chen J., Kang B., Jiang Q., Han M., Zhao Y., Long L., Fu C., Yao K. (2018). Alpha ketoglutarate in low-protein diets for growing pigs: effects on cecal microbial communities and parameters of microbial metabolism. *Front. Microbiol*., 9: 114.

Chmielowiec-Korzeniowska A., Tymczyna L., Pyrz M., Trawińska B., Abram c zyk K., Dobrowolska M. (2018). Occupational exposure level of pig facility workers to chemical and biological pollutants. *Ann. Agric. Environ. Med*., 25: 262–267.

Colina J., Lewis A., Miller P.S. (2000). A review of the ammonia issue and pork production. *Nebraska Swine Rep*., 108: 2425.

Commission Implementing Decision (EU) 2017/302 of 15 February 2017 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the intensive rearing of poultry or pigs.

Eriksen J., Nørgaard J.V., Poulsen H.V., Jansen B.B., Petersen S.O. (2014). Effects of acidifying pig diets on emissions of ammonia, methane, and sulfur from slurry during storage. *J. Environ. Qual*., 43: 2086–2095.

Girard M, Nikiema J, Brzezinski R, Buelna G, Heitz M. Can J Civ Eng. 2009; 36:1946-1957. DOI: 10.1139/L09-141.

Hansen *et al*. (2013), "Characterization of odorant emissions from pig production: Focus on indole and skatole," Atmospheric Environment, 76, 22–29.

Hansen M.J., Jonassen K.E.N., Lokke M.M., Adamsen A.P.S., Feiberg A. (2016). Multivariate prediction of Odor from pig production based on in-situ measurement of odorants. *Atmos. Environ*., 135: 50–58.

Kaufmann, T. (2015). Sustainable Livestock Production: Low Emission Farm. The Innovative Combination of Nutrient, Emission and Waste Management with Special Emphasis on Chinese Pig Production. *Animal Nutrition*, vol. 1, issue 3, pp. 104-112.

Kim KY, Ko HJ, Kim HT, Kim YS, Roh YM, Lee CM, et al. Environ Monit Assess. 2007;133:255-266. DOI: 10.1007/s10661-006-9578-x.

Kwiecińska A, Konieczny K. Ecol Chem Eng A. 2013;20(2):239-249. DOI: 10.2428/ecea.2013.20(02)024.

Loyon, L., *et al*. (2016). Assessment of NH3 reduction and N2O Production during Treatment of Exhausted Air from Fattening Pigs Building by a Commercial Scrubber. *Agricultural Sciences*, vol. 7, issue 10, pp. 693-709.

Marszałek M., Kowalski Z., Makara A. (2018). Emission of greenhouse gases and odorants from pig slurry – effect on the environment and methods of its reduction. *Ecol. Chem. Eng. S*., 25: 383–394.

Martinez J, Guiziou F, Peu P, Gueutier V. Biosyst Eng. 2003;85(3):347-354. DOI: 10.1016/S1537- 5110(03)00067-9.

Mohajan H.K. (2012). Dangerous effects of methane gas in atmosphere. *Internat. J. Economic Political Integrat*., 2: 3–10.

Mohajan H.K. (2012). Dangerous effects of methane gas in atmosphere. *Internat. J. Econom. Politi cal Integrat*., 2: 3–10.

Ni *et al*. (2010), "Formation and emission of odor compounds in pig manure and mitigation by dietary modification," Journal of Environmental Sciences, 22(1), 62–66.

Panday, U. K., Singh, M. P., & Ram, M. (2013). Pig farming in Haryana: Prospects and retrospects. *The Indian Journal of Animal Sciences*, 67(1).

Philippe F., Nicks B. (2015). Review on greenhouse gas emissions from pig houses: Production of carbon dioxide, methane and nitrous oxide by animals and manure. *Agric. Ecosys. Environ*., 199: 10–25.

Recharla N., Kim K., Park J., Jeong I., Jeong Y., Lee H., Hwang O., Ryu J., Baek Y., Oh Y., Park S. (2017). Effects of amino acid composition in pig diet on odorous compounds and microbial characteristics of swine excreta. *J. Anim. Sci. Technol*., 59: 28–36.

Reddy, G.B., & Pant, S.C. (2013). Emerging zoonoses associated with pig farming. Veterinary World, 6(11), 855-860.

Rodriguez M.R., Losada E., Besteiro R., Arango T., Velo R., Ortega J.A., Fernan dez M.D. (2020). Evolution of NH3 concentrations in weaner pig buildings based on setpoint temperature. *Agronomy*, 10: 107–114.

Wuana, R.A., & Okieimen, F.E. (2011). Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation. ISRN Ecology, 2011, Article ID 402647.