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Environmental Health Landfill Management – Heat Transfer Modelling at Soil Materials for Agricultural Food Protection and Sustainability

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Abstract

The underground vertical lateral soil barrier design adjacent to boundaries of landfill sites, for the environmental health management of landfill emissions and waste biodegradation is reviewed for agricultural food and public health protection. The aim is to better understand the role of heat transfer at undergound soil materials as barriers for agricultural food protection and sustainable development within landfill biodegradation processes on the landfill gas migration and efficient economic designs in relation to landfill emissions management techniques. The variations of heat transfer and landfill gas migration next to landfill boundaries are evaluated. The field data confirm that waste pretreatment and leachate recirculation are sustainable and accelerate the waste biodegradation within landfill biotechnologies in time protecting agricultural resources and public health from associated toxic chemical hazards. In this study is investigated the right operational project management of efficient heat transfer design related to soil materials within geoinformation numerical simulation utilities. Also a risk assessment monitoring framework is presented for agricultural food protection and sustainability of associated efficient infrastructures in circular economy that promote safe environmental ecological community health facilities.

Keywords: Efficient landfill biotechnologies in circular economy; heat transfer modelling; monitoring schemes for agricultural food protection; soil and other construction materials; ecological health and forest protection; efficient community health infrastructures; geoinformation utilities; public health protection; fluid mechanics.

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1. INTRODUCTION

Landfills can produce objectionable odors and landfill gas can move through soil and collect in nearby buildings. Of the gases produced in landfills, sulfides, ammonia, methane, carbon dioxide and V.O.C's are of most concern. Hydrogen sulfide and ammonia are responsible for most of the odors at landfills. Methane and carbon dioxide can also collect in nearby buildings and displace oxygen. Methane is flammable and concentrations have sometimes exceeded explosive levels indoors. Both methane and carbon dioxide are greenhouse gases provoking the global warming. This fact sheet provides information on what efficient designs and measures can be taken to prevent gases from leaving landfill boundaries and entering off-site structures, nearby agricultural food production facilities, other sustainable development land uses and how building owners, operators can reduce landfill gas collection indoors, particularly in confined areas like basements, crawl spaces and other associated spaces for public and community health protection [12, 23, 24, 26, 30, 34, 36, 38, 44].

Landfill gas contains many different gases. Methane and carbon dioxide make up 90 to 98% of landfill gas. The remaining 2 to 10% includes nitrogen, oxygen, sulfides, ammonia, hydrogen, and various other gases. Landfill gases are produced when bacteria break down organic waste. The amount of latter gases depends on the type of waste-treatment biotechnology present in the landfill design, the age of the landfill, oxygen content, the amount of moisture, temperature, gas pumping pipe network and lateral heat transfer control at vertical soil barriers [7, 10, 29, 36, 44].

Therefore, biogas production will increase if the temperature or moisture content increases. Though production of these gases generally reaches a peak in time, a landfill can continue to produce gases for long term periods. Landfill gas contains many different gases. Proper heat transfer control designs are necessary within vertical lateral soil barriers at landfill boundaries. In this way following the right monitoring geoinformation tools proper agricultural food protection will be achieved at relative nearby agricultural land uses or other ones that promote sustainability and ecological health like integrated infrastructures at nearby forests.

Methane and carbon dioxide make up 90 to 98% of landfill gas. The remaining 2 to 10% includes nitrogen, oxygen, ammonia, sulfides, hydrogen, and various other gases. Landfill gases are produced when bio-degradation bacteria break down organic waste. The amount of these gases depends on the type of waste present in the landfill, waste per-treatment techniques, the age of the landfill, oxygen content, the amount of moisture, and temperature. For example, gas production will increase if the temperature or moisture content increases. Though production of these gases generally reaches a peak approximately in one to seven years, which depends on particular process design within landfill biotechnology's related to hydraulic, drainage, geotechnical construction design. The right operational management of a heat transfer design is investigated related to soil materials within geoinformation numerical simulation utilities and associated risk assessment framework for sustainability of efficient infrastructures in circular economy and environmental health protection [29, 30, 31, 34, 46].

2. MATERIALS AND METHODS - LITERATURE REVIEW

Nowadays, emerging environmental technologies are necessary for heat transfer problems to be solved properly providing useful solutions to particular anthropogenic activities [31, 51, 52, 53, 54, 55, 56, 57]. Moreover, environmental health sanitary technologies within Solid Waste Management are necessary for effective landfill biotechnologies with proper exploitation of landfill emissions in circular economy and public ecological health protection in particular ecosystems [33, 34, 35, 42, 45]. Landfill gases can move from a landfill through soil into outdoor air as well as the indoor air of nearby buildings. Landfill gases in outdoor air can enter a building through doors, windows and ventilation systems. In soil, landfill gases can migrate and enter a building through cracks in the basement floors and walls, utility entry points (e.g., where underground water or electrical lines enter a building), sump pump holes or floor drains. This is called soil vapor intrusion. Once they enter a building, landfill gases may collect in areas of poor ventilation, such as crawlspaces, basements, and underground utility tunnels [9, 18, 19, 20, 21, 23, 36].

Moreover, important things for monitoring schemes to know about landfill heat emissions, biogas migration that can produce objectionable odors and landfill gas can move through soil and collect in nearby buildings, agricultural greenhouse constructions or other nearby land uses causing particular environmental impacts. Of the gases produced in landfills, sulfides, ammonia, methane, and carbon dioxide are of most concern. Ammonia and hydrogen sulfide are responsible for most of the odors at landfills, associated environmental health risks and relative measures should be taken for public health protection [5, 36, 37, 39, 40, 44].

However, methane is flammable and concentrations have sometimes exceeded explosive levels indoors. Methane and carbon dioxide can also collect in nearby buildings and displace oxygen. This fact sheet provides information on what measures can be taken to prevent gases from leaving landfills and entering off-site structures and how building owners can reduce landfill gas collection indoors, particularly in confined areas like basements and crawl spaces.

Moreover, odors from Landfill Gas Odors in landfill gas are caused primarily by hydrogen sulfide and ammonia, which are produced during breakdown of waste material. For example, if construction and demolition debris contain large quantities of wallboard (also called drywall or gypsum board), large amounts of hydrogen sulfide can be formed. Hydrogen sulfide has the foul smell of rotten eggs, while ammonia has a strong pungent odor. Humans can detect hydrogen sulfide and ammonia odors at very low levels in air, generally below levels that would cause health effects [26, 36, 44].

Health Effects of Ammonia and Hydrogen Sulfide Short-term exposures (typically up to about two weeks) to elevated levels of ammonia and hydrogen sulfide in air can cause coughing, irritation of the eyes, nose, and throat, headache, nausea, and breathing difficulties. These effects usually go away once the exposure is stopped. Studies have been conducted in communities near landfills and waste lagoons to evaluate environmental health effects associated with exposure to landfill gases. These studies lasted for several months and reported health complaints which coincided with periods of elevated levels of hydrogen sulfide and landfill odors. The reported health complaints included eye, throat and lung irritation, headache, nausea, nasal blockage, sleeping difficulties, weight loss, chest pain, and aggravation of asthma. Although other chemicals may have been present in the air, many of these effects are consistent with exposure to hydrogen sulfide [12, 18, 22, 23, 24, 26, 30, 46].

Therefore, dynamic numerical simulation models based on field data should be used for the right heat transfer design within soil materials as barriers for agricultural food protection and environmental health protection from associated landfill emissions. Dynamic numerical simulation models are necessary within fluid mechanics – heat transfer using proper software programming languages so as to predict with better accuracy the particular fluid mechanics characteristics or chemical landfill emissions' magnitudes for the right process management; life cycle analysis; geoinformation utilities; monitoring schemes; pumping pipe networks for biogas collection systems and spatial risk analysis in time for sustainability and public health protection [8, 11, 13, 17, 25, 27, 30, 40, 47, 48, 50].

Moreover, dynamic lining methods should take place based on the numerical simulation results, risk assessments for public health, environmental impact assessments and monitoring data for the right decision making in measures, maintenance and probable reclamation works for agricultural food protection in time on given landfill topographical characteristics. The produced landfill emissions, gases and leachates, should be monitored properly for public health protection. Landfill emissions are a result from the waste biodegradation of the organic material which has been disposed into the landfill mass [41,42,43,49,71]. Below useful numerical results are presented for the right heat transfer design at landfills based on the case study of sanitary engineering landfill at Mid Auchencarroch (MACH) experimental landfill four-cell site.

3. RESEARCH METHODOLOGY

A target of an efficient landfill biotechnology project is to show that shallow landfill of solid waste is feasible in terms of establishing and maintaining a suitable environment for methanogenic degradation to occur at significant rates. The experimental element of the MACH project, is a test bed for a shallow landfill bioreactor and its control as an enhanced degradation system. The results of landfill emissions and relative geoinformation ICT's tools for landfill design process management are useful for environmental health protection and circular economy.

It is possible to control and enhance landfill gas production and flush potential pollutants from the waste mass, by manipulating the whole process of landfill. Shallow landfill concept can be used as a sequential batch bioreactor which could be an economic solution for communities within sustainable development not only for developed countries but also for developing countries [14, 35, 36, 44, 49].

However, the treated landfill emissions can be used properly to support agricultural development works or other recreational activities at integrated infrastructures at agricultural land uses next to forests for community health, public health protection i.e. greenhouse heating; electricity produced by landfill gas for pumping machines in irrigation – drainage systems; treated leachates for irrigation projects supporting phytoremediation projects for reclamation of polluted soils by heavy metals, supporting associated planting activities for environmental health protection and sustainable development [34, 36, 44]. Careful design and engineering of the proper landfill cells and soil materials are considered to be important, so that an effective design to be arrived at without excessive construction costs. Shallow landfill is particularly sensitive in this respect due to the higher plan area / volume ratio [27, 29, 31, 32].

This section analyzes the modeling of heat transfer design taking into account vertical soil materials and landfill temperature control measures based on field data of Mid Auchencarroch (MACH) experimental landfill project. It is located next to Alexandria area, between the Loch Lomond and Kilpatrick hills outside from Glasgow city, in Scotland [29, 30].

It has been constructed in order to assess a number of techniques that promote sustainable landfill design protecting environmental health. MACH experimental landfill, is an Environment Agency, DTI and industry funded research facility. MACH experimental batch anaerobic landfill bioreactor has been capped since November 1995. The experimental variables are waste pretreatment, wet biomass pulverization, leachate recirculation and codisposal with inert material. The experimental landfill Mid Auchencarroch is a field scale facility which is consisted of four cells each of nominal volume 4,200 m3 [29, 30, 34].

The total MACH waste mass depth is 5 meters, without the topsoiled surface cap depth. In cells 1 and 3 there is pretreatment by wet pulverization and in cells 2 and 4 the disposed waste is untreated. In cells 1, 2 and 3 there is recirculation of leachate and in cell 1 there is addition of inert material 20% by volume [29, 30, 32, 34]. MACH experimental project examines techniques so as to enhance the waste degradation, pollutant removal processes and control of landfill emissions.

The MACH experimental landfill project has presented a number of waste management techniques that accelerate waste biodegradation and heat generation, minimizing the associated environmental impacts of landfill emissions [29, 30, 31]. The wet-flushing sequential batch bioreactor landfill model is seen as the method of achieving the goal of sustainable development. The examining experimental and computational data, which are presented below, cover the time period of the first two year of waste biodegration at MACH site. According to MACH landfill emissions, evaluating and analyzing them, it is clear that methanogenesis was achieved in short time period.

The most crucial period at MACH for landfill gas peak production and peak temperature reached in the first 105 days of biomass biodegradation since MACH site was capped. Moreover, leachate emissions and their respective pH values stabilized in the first 22-month period of biomass biodegradation since MACH site was capped [29, 30, 31]. For MACH the higher temperature in the waste mass is taken at the landfill mid-depth. However, there have been found the following useful heat generation heat generation source terms at MACH site mid depth, in order to evaluate biomass biodegradation parameters under different solid waste management techniques, which are presented below.

The heat generation source terms for the three different examining waste types in MACH cells, after calibration, are the followings [30, 31] :

αwt1 = 1.18 Dwaste Gt 0.41 e-l t (1)

αwt2 = 1.18 Dwaste Gt 0.68 e-l t (2)

αwt3 = 1.18 Dwaste Gt 0.89 e-l t (3)

where

αwt1 : heat generation source term at landfill mid-depth for waste type of co-disposal of pulverized waste with inert material (Kcal/m3 day)

αwt2 : heat generation source term at landfill mid-depth for pulverized disposed material (Kcal/m3 day)

αwt3 : heat generation source term at landfill mid-depth for untreated disposed material (Kcal/m3 day)

Dwaste : waste density (kg/m3)

Gt : LFG production in time (m3 LFG/1,000 kg waste day)
l : biodegradation rate (day-1) t : (day)

During the decreasing period of biogas production l depends on the k kinetic parameter of landfill gas production.

Substituting equation (1) or (2) or (3) to (4) yields the governing equation for the landfill mid-depth temperature and heat transfer in one dimension, in a homogenous landfill like MACH one.

$$\frac{\partial U(y,t)}{\partial t} - \beta \frac{\partial}{\partial y}\left(\frac{\partial U(y,t)}{\partial y}\right) = \alpha \quad (4)$$

where

$\beta = k/\rho Cu$ k : thermal conductivity (kcal/ day m °C)

ρ : density (kg/m3) Cu : heat capacity (kcal/kg °C)

U : temperature in vertical location in Y axis (o C) t : time (day) y : vertical distance in landfill depth (m)

α : heat generation source term (kcal/m^3 day)

Based on the above presented numerical simulation module as a geoinformation utility that was solving the coupling of equations (1), (2), (3), (4) then the results could be compared with the experimental MACH field data. That geoinformation utility could be useful for monitoring tools and operational project management of landfill biotechnologies for public health protection. Based on the field data and the numerical results, it was clear that the particular numerical modules operate efficiently, giving satisfactory results [29, 30, 31].

The output results could be saved in data sets forms, relative files, which can be easily manipulated by the user, applying them in several types of digital spatial geoinformation databases, I.C.T's or web Geographical Information Systems for further spatial analysis – project management within agricultural food protection, e-learning utilities and probable reclamation works based on any particular landfill topography characteristics for public health protection [11, 17, 28, 30, 32, 37]. The experimental field data from Mid Auchencarroch batch experimental bioreactor show that waste biodegradation has been achieved in a short time, minimizing any hazards of landfill emissions to natural resources or anthropogenic properties over the longer term [29].

Uncontrolled dumps or landfills with high putrescible waste fractions should close to prevent plant asphyxiation related to either agricultural food protection or phytobioremediation projects for soil reclamation, landscape degradation, flora and fauna degradation, gas explosions and landfill fires next to buildings and associated community health facilities next to forests. Efficient geoinformation utilities and ICT's are necessary for operational project management, risk analysis monitoring schemes and maintenance designs related to upgraded old landfill sites' landscapes – nearby forest landscapes, utilizing properly emerging clean technologies associated with landfill emissions for sustainable development in circular economy [12, 14, 23, 29, 36, 44, 45].

Efficient anaerobic landfill sequential batch bioreactors, such as MACH, should be used to minimize any risks from landfill emissions. Based on the biomass's peak temperature and waste input, certain physical properties can be calculated. These include the LFG migration (by advection) velocity, which is analyzed below. Inside the waste mass, before biogas generation starts, a pressure of 1 atmosphere exists, as existed during waste disposal. The gas pressure change due to gas generation in the waste mass, in time, provokes a gas velocity Ug, which follows Darcy's law, as presented below [30, 31].

$$Ug = -\frac{k}{\mu}\frac{\Delta Pg}{\Delta h} \quad (5)$$

where

Ug : advection velocity (m / sec) μ : gas viscosity (N-s / m2)

k : intrinsic permeability (m2) P : pressure (N/m2)

h : vertical distance (m) If we will take into account

that for a given Δh', inside the landfill in vertical direction there is gas change pressure ΔP'g, then for a specific area S, into which gas enters, we will have, from equation (5).

$$SU'g = \frac{k}{\mu}\frac{\Delta P'g}{\Delta h'}S \quad (6)$$

The term S U'g defines a volumetric flow (m3/ s) over time, which equals to the volume production rate of the generated gas in the waste mass.

Also valid is that G't = Gt/d (m3 gas / m3 waste), where Gt is calculated LFG production quantities, and d is the waste density (t/m3), with conversion to the relative units. For a given area S and change of height h', the produced volume of gas, will be G't S Δh. The intrinsic permeability for the waste porous medium is taken as the value of 1 Darcy or 10-12 m2 [31, 34, 44].

Hence, we will have the following.

$$G''_t S\Delta h' = \frac{k}{\mu}\frac{\Delta P'g}{\Delta h'}S \quad (7)$$

or

$$\Delta P'g = G'_t\,\Delta h'^2\,\frac{\mu}{k} \quad (8)$$

where

G't : gas generation (m^3 gas/s m^3 waste)

P'g : gas pressure in the waste mass (N/m^2)

μ : gas viscosity (N^{-s} / m^2)

k : intrinsic permeability (m^2)

P : pressure (N/m^2)

h : vertical distance (m)

Equation (8) calculates the gas pressure over atmospheric pressure in the waste mass. However, as the volume G't is calculated at standard temperature and pressure conditions, conversion of this volume to landfill mid-depth temperature, using the state equation, gives an increase in its value (taking for a given gas that the ratio of temperatures is analogous to the ratio of volumes under constant pressure conditions). Viscosity also changes due to temperature and for a given average biogas synthesis with 60% methane by volume and 40% carbon dioxide by volume is calculated by the following equation [30, 31, 34, 44].

μ_{lfg} = 0.6 μ methane + 0.4 μ carbon dioxide (9)

where μ : gas viscosity (N-s / m2) μ methane : (1.935 + 0.0305 T) 10-6 μ carbon dioxide : (-30.212

+ 0.256 T - 0.00035 T2) T : temperature in Kelvin

Based on the above could be used a useful numerical software utility for ecological environmental health protection, sustainable development projects related to SI Mulation landfill construction design biotechnology GAS RISK (SIMGASRISK) assessment numerical modeling geoinformation software results, combining all the above presented associated computational modules.

The relative SIMGASRISK's geoinformation software numerical modeling results could be useful for environmental impact assessments; efficient hydraulic projects; innovative construction material designs; quality assurance projects; public health protection; associative sustainable designs so as to quantify and examine the peak biogas - heat emissions for different waste types in anaerobic batch landfill bioreactors for MACH landfill conditions or similar ones after proper modification. Moreover, the results are useful for projects within fluid mechanics and health protection; monitoring schemes; epidemiological studies; environmental protection; landfill emissions process management and life cycle analysis within landfill designs taking the right decisions in time minimizing the associated risks, toxic hazardous emissions, environmental impacts so as to secure ecological health protection.

Proper constructions of soil materials at landfill biotechnologies - construction designs should take place taking into account efficient heat transfer designs for sustainability and public health protection [29, 30, 31, 32, 33, 34, 43, 47, 50]. A numerical modeling solution of heat transfer could be realized for the above purposes solving the lateral temperature regime in one meter clay width next to landfill boundaries. The governing equation of this phenomenon in four dimensions, 3-D in space and 1-D in time, is given below [30, 31]:

$$\frac{\partial U(x,y,z,t)}{\partial t} - \beta \frac{\partial^2 U(x,y,z,t)}{\partial x^2} - ,$$
$$\beta \frac{\partial^2 U(x,y,z,t)}{\partial y^2} - \beta \frac{\partial^2 U(x,y,z,t)}{\partial z^2} = \alpha \quad (10)$$

where

β = k/ρCu k : thermal conductivity (kcal/ day m °C)

ρ : density (kg/m3) Cu : heat capacity (kcal/kg °C)
U : temperature in vertical location in Y axis (°C)

t : time (day) x, y, z : spatial location in x, y, z axis (m)

α : heat generation source term from landfill mass material (kcal/m^3 day)

Due to the fact that the examining one meter in width clay barrier next to landfill boundaries is assumed that has a homogenous material the same results approximately will give the selection of the numerical solution of the 2-D in space heat transfer equation problem.

The latter selection could make not only quicker numerical solutions than the computation of 3-D in space problem for long time-series but also the numerical results could be manipulated easy in any spatial digital geoinformation databases and associated risk assessments in spatial analysis.

The numerical solution of the above governing equation gives higher temperature inclination in the middle of the examining clay barrier as it is shown in figure 1, taking into account the temperature boundaries conditions next to the landfill mass in one meter width of a homogeneous clay barrier and as height the landfill depth [30, 31].

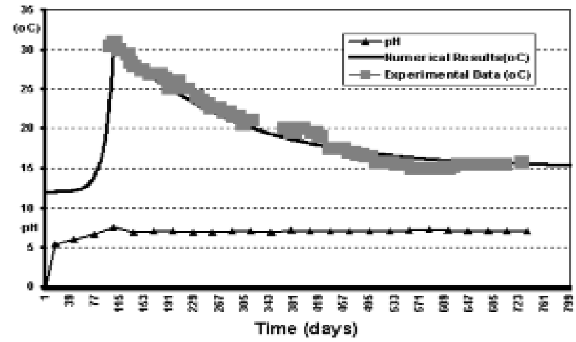

Figure 1. Measured vs calculated biomass temperature and pH values from landfill emissions at MACH cell 1. Source: [31]

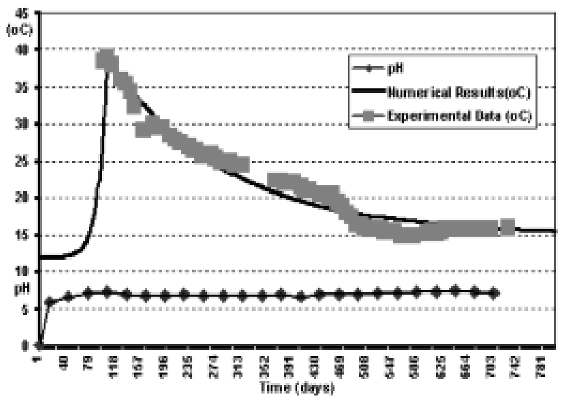

Figure 2. Measured vs calculated biomass temperature and pH values from landfill emissions at MACH cell 2. Source: [31]

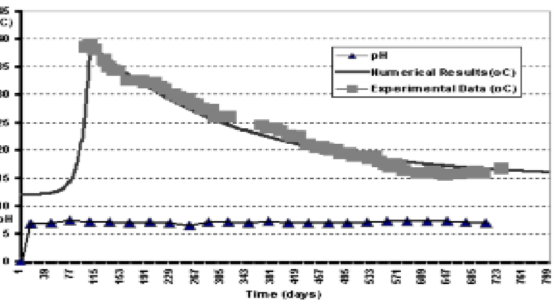

Figure 3. Measured vs calculated biomass temperature and pH values from landfill emissions at MACH cell 3. Source: [31]

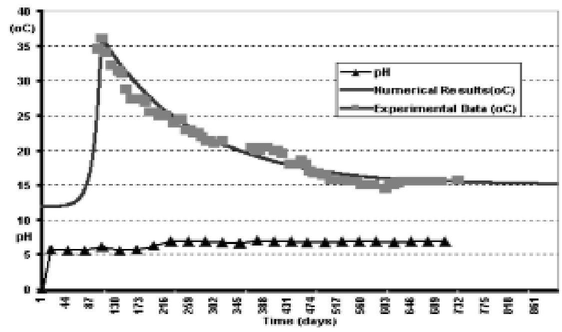

Figure 4. Measured vs calculated biomass temperature and pH values from landfill emissions at MACH cell 4. Source: [31]

Based on the proper numerical solution (3-D) finite difference approximation scheme for the solution of the relative differential equation (10) are calculated the relative useful geoinformation results of heat transfer in vertical soil materials within one-meter selected width for environmental and public health protection [30, 31, 33].

Equation (10) has been solved for heat transfer problem in particular soil material properties at a grid point (x,y,z) applying properly the explicit finite difference method, using forward time central space discretization, that provides satisfactory stable results based on the relative applied finite difference scheme [30, 31, 50, 51,52, 53, 54, 55, 56, 57].

The parameters that have been taken into account for the relative heat transfer numerical simulation are the D : density of the porous medium (kg/m^3); KC : thermal conductivity (kcal/ day m °C); CY : heat capacity of the medium (kcal/kg °C); Δx, Δy, Δz: discretization parameters in X, Y, Z axes; Δt : discretization parameter in time; U : temperature on the particular node of the grid in particular x, y, z location and in time t; α : source term (kcal/m^3 day).

The stability conditions have been verified for the relative heat transfer simulation design so as to achieve agricultural food protection and environmental ecological health at nearby relative land uses [30, 31, 33, 34]. Based on the above described modules of heat generation results have been taken into account the soil material properties on landfill boundaries so as to model the process management, life cycle analysis of landfill designs.

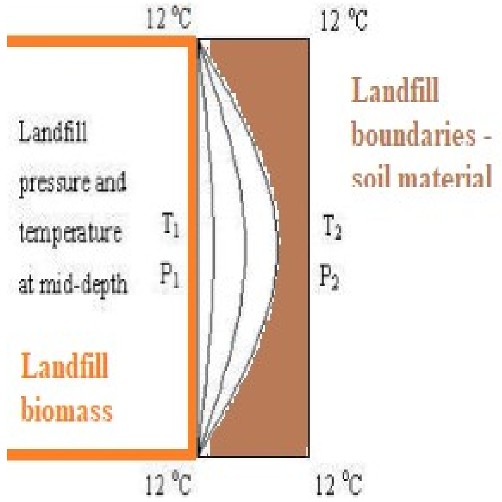

Figure 5. Heat transfer trends within vertical soil material for MACH cells, sanitary drawing for monitoring schemes.
Source: [31]

In figure 5, are presented the relative heat transfer trends for the case study of MACH experimental landfill site for the four cells at one meter width based on relative sanitary drawing for monitoring schemes and proper quality management taking into account boundary conditions and characteristics of soil material [30, 31]. Based on the above, in Table 1 is presented the calculation of biogas migration pressure at landfill boundary below in relation to biomass temperature, soil boundary temperature (12 °C) and landfill gas production rate [29, 30, 31, 33]. The results could be combined with other future research investigations based on field data between biomass and various soil properties, associated construction designs related to geological strata conditions outside from landfill boundaries.

Moreover, the results are useful so as to set up the right geoinformation life cycle analysis; landfill biotechnology process management; associated monitoring techniques; smart sensors; I.C.T's and maintenance project management tools for integrated community ecological health infrastructures and sustainable development in circular economy [29, 31, 32, 33, 38, 45].

In Table 1, are presented the calculated numerical results of biogas emissions, based on proper computational fluid mechanics dynamics, applying all the relative formulas to conditions in MACH cells 1, 2, 3 and 4, for the crucial period where landfill gas peak production and peak temperature reached in the first 105 days of biomass biodegradation since MACH site was capped [30, 31].

Table 1. Numerical Results of Landfill Gas Emissions

Landfill site Case Study	Pressure of landfill gas (N/m^2)	Landfill boundary lateral soil temperature (degrees C)	Landfill production rate (m^3 gas/t waste)
MACH CELL 1	1250	31	33.1
MACH CELL 2	2361	39	37.8
MACH CELL 3	1506	39	32.8
MACH CELL 4	2340	36	36.1

Source: [31]

In addition to the above the right sanitary drawings should be taken into account for the right operational project management at landfills that are located at nearby community health tourism centers, anthropogenic land uses, other ecological health infrastructures like forests, lakes, sea coasts or other environmental resources [30, 31, 34].

Moreover, the right phytobioremediation projects should be applied properly for environmental health quality at top soils of landfill sites mitigating any associated pollution threats not only for environmental health but also to be exploited as biofuels the used operational relative plants at polluted soils located at areas next to quarries or other land uses like landfill sites taking the right associated monitoring schemes and actions for sustainability and environmental health protection [1, 2, 3, 4, 6, 15, 16].

In this way all the above presented could be useful for future sustainable development designs not only promoting proper emerging technologies for public environmental health protection but also new ones for sustainability; creation of jobs and circular economy in society. Proper maintenance designs should take place for vertical soil barriers located at landfill boundaries should take place in cases of extreme flood events, earthquakes or other types of storms due to climate change taking into account landfill process management, life cycle analysis of biotechnologies, construction design material properties, risk assessments and particular geoinformation results [33, 34]. All the above presented should be taken into account for the right set up of efficient monitoring schemes and sanitary drawings related to landfill biotechnologies related to agricultural food productivity protection at land uses located close to landfill boundaries protecting public health, see figure 6 [34].

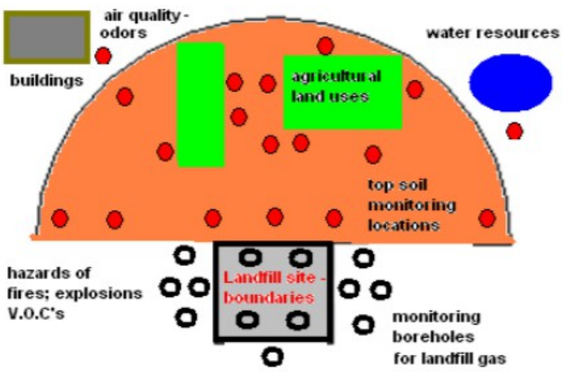

Figure 6. Sanitary drawing for the right monitoring locations of soil, environmental health resources from biogas migration for agricultural land uses next to landfill boundaries. Source: [34]

Treated leachate emissions, drainage designs and collected biogas emissions either from landfills or from waste water units [35, 36, 44] can be used properly for water resources recovery, agroponic projects, irrigation projects, environmental health protection, electricity and heating renewable resources, relative resources for the proper treatment at efficient eco-friendly construction materials, covering proper necessities at greenhouse facilities for agricultural food production of community health centers at associated ecological locations or upgraded landscapes of old closed landfill sites [14, 20, 21, 29, 30, 31, 32, 35, 36, 44].

Therefore, based on the MACH's experimental landfill results in terms of LFG production and gas migration, respectively, a higher risk exists in cells 2 and 4 than in cells 1 and 3 for gas explosions, environmental pollution and damage to particular agricultural properties for food production, storage under unfavorable conditions [29, 30, 31, 32]. Proper geoinformation utilities should take place for the safe and qualitative operation of particular infrastructures related to environmental ecological health. In Table 2, are presented Adverse Impact Issues of Waste Management Units on Receptors of Nearby Environmental Health Infrastructures, Agricultural Food Production and associated Properties, infrastructures related to sustainable eco-health in circular economy. The relative geoinformation numerical results could be used as a useful quality management utility of landfill emissions for sustainable development projects i.e. innovative construction designs for medical sports, efficient medical tourism facilities, ecological health training infrastructures, community health facilities within forests and qualitative ecological water resources etc.

Applying properly the above landfill design principles as well as relative quality process management, taking into account the properties of soil and land filled materials that have been used, it will be useful for quality control avoiding of hazardous emissions like:

- Methane, Carbon Dioxide and V.O.C's so as to protect Public Health from Explosions, Toxicity to Plants, Landscape ecological degradation, Loss of Building Properties;
- Illegal Roadside Dumping and leachate toxic emissions to associated agricultural resources, soil resources, water resources from uncontrolled dumps proposing reclamation proper reclamation projects
- Truck Traffic in waste management and noise pollution, air pollution proposing reclamation works near Landfill;
- Congestion, Air Pollution, Water Pollution, Soil Pollution, Aesthetics, Sustainable Development Economics, Public Health.

Table 2. Adverse Impact Issues of Waste Management Units on Receptors of Nearby Environmental Health Infrastructures, Agricultural Food Production and Properties.

Steps	Activities	Steps (continued)	Activities (continued)
1	Installation of monitoring boreholes – data collection & analysis*	5	Planning of alternatives
2	Development of goals and objectives	6	Recommendation of actions and evaluation
3	Clarification and diagnosis	7	Development of an implementation program
4	Indentification of alternative solutions	8	Monitoring and surveillance in time

Source: [30]

Principles of occupational medicine, efficient construction designs for storage of agricultural goods, effective shipment of goods for sustainability, monitoring pipe networks, smart sensors and biostatistics should take place applying the right geoinformation utilities for community health centers, associated nursing infrastructures at ecological health centers and public health protection [5, 26, 28, 44]. Also efficient manufactures, 3d printing simulation tools and efficient sustainable technologies should be applied properly so as to take the right measures and actions in emergencies according to the results of spatial environmental health analysis based on efficient geoinformatics utilities [20, 21, 28, 36, 44]. Based on the above geoinformation analysis proper monitoring schemes should exist for landfill emissions as they could be located also next to landfill boundaries to allow measurement of particular landfill emissions, minimizing associated risks, for ecological health protection at particular sustainable community health infrastructures located next to fabulous ecosystems like lakes, rivers, waterways, coasts, forests, water facilities and upgraded landscapes of old landfill sites [29, 30, 31, 33, 34, 35, 36]. Based on the above proper landfill design and monitoring geoinformation tools are needed to be applied not only for new landfill operations but also at old landfills for an integrated upgrade of landscape linked with nearby forests, water ways for sustainable ecological community health tourism destinations.

Following all the above could be avoided landfill fires that may or may not be directly caused by landfill gas; however, because of the potential health and safety issues that they pose (e.g., gases released during the fire), this primer provides information about landfill fires. If conditions are right, landfill fires can burn underground. The heat from the fire can cause toxic chemicals to volatilize or break down and enter the environment to nearby indoor, outdoor spaces. Consumer products in a landfill are the most likely source of chemical releases; these products may include paints, cleaners, pesticides, solvents, or chemical additives. Underground fires are extremely difficult to combat and can burn for days or even weeks. These toxic chemicals may be released in smoke from the fire.

Currently, no scientific publications are available that address health effects from inhaling smoke produced during landfill fires. In order to answer concerns about potential health effects of smoke, a health professional can evaluate potential health effects posed by the particulate matter and individual chemicals emitted during the fire.

However, it is important to note, however, that although a single chemical in the smoke may not be present in concentrations that are high enough to cause health effects, the effects of a combination of chemicals may produce unknown health reactions. Ambient air sampling and monitoring data from the community can most accurately identify the contaminants being released during the fire. Proper measures and guidance are necessary to be taken by Local Authorities if the air pollutant concentration increases, it may be appropriate to evacuate people within a certain radius of the landfill [5, 12, 28, 30].

4. CONCLUSIONS

As well as the fact that methane is the major component of natural gas proper landfill gas pipe network design should exist for biogas collection. Moreover, efficient hydraulic projects within construction landfill designs and right economic solutions in heat transfer designs should exist for soil materials that exist at landfill boundaries protecting public health and agricultural food at nearby land uses. The proposed fluid mechanics solutions, relative sustainable solutions for agricultural food protection and associated geoinformation results could be useful to be applied in future sustainable development economic designs and biotechnologies for developing countries.

Methane is highly flammable and can form explosive mixtures with air if it concentrates in an enclosed space with poor ventilation. The range of air concentrations at which methane levels are considered to be an explosion hazard is 5 to 15% of the total air volume. Monitoring schemes, life cycle analysis, maintenance designs, risk assessments and reclamation works should exist in time when hazards and associated risks exist from landfill emissions for specific case studies.

The presented outcomes could be applied properly in sanitary environmental engineering designs applying proper geoinformation utilities, I.C.T's in decision making for taking measures in time for sustainable development at community health centers; medical tourism facilities; nursing infrastructures and ecological health infrastructures at clean environments on mountainous topographies next to forests and clean environmental healthy ecosystems. These measures could be taken into account for medical health facilities, ecological health facilities, forest infrastructures for medical sports, ecological tourism facilities and community health infrastructures within agricultural food protection, integrated community health infrastructures at nearby forests, lakes, upgraded landscapes at old landfills, sustainable development in circular economy and environmental ecological public health protection.

Future proper landfill construction designs; process biotechnology management; monitoring bio-sensors; geoinformation utilities; life cycle analysis of landfill chemical emissions; quality control tools and chemical toxicity's risk assessment utilities should be focused on innovative materials for the associated control of lateral heat transfer, associated hazards and mitigation of probable pollution from landfill emissions. In this way not only exists agricultural food security to any nearby agricultural infrastructures from landfill boundaries but also there is public health protection minimizing associated ecological health risks, environmental health impacts.

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