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Environmental Health Landfill Emissions – Environmental Resources Utilities for Soil Health and Sustainable Development

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Abstract

This paper analyses the role of environmental utilities in terms of public health protection and sustainability from landfill emissions. Useful analysis is taken into account based on hydraulics so as to mitigate rheological toxic hazardous concentrations at landfill's biodegradation - bottom leachates migration and efficient economic designs. Integrated management techniques are presented for landfill emissions. Useful results are presented for the safety of veterinary units, safe sports physical activities for all and sustainable tourism infrastructures.

Keywords: sustainable designs; monitoring schemes for agricultural food safety; soil health; circular green social economy; sustainable construction design materials; sustainable ecological health tourism infrastructures; medical tourism; forest facilities protection; safe veterinary units; safe sports physical activities; geoinformation utilities; digital image processing; public health protection; fluid mechanics; rheology; clean technologies; COVID-19.

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1. INTRODUCTION

Nowadays, particular environmental hazards exists at landfills including downgrade of flora - fauna, ecological health tourism downgrade due to uncontrolled land uses [1,10,12,14,19, 23, 24, 26,28, 30, 32, 65,66,68,75, 80, 82, 93].

Moreover, useful geo-information utilities are necessary as well as proper methodologies to be used in order to protect public health and upgrade relative medical tourism infrastructures at the post COVID-19 pandemic era [3, 11, 82, 93].

Risk assessment tools combined with smart engineering ICT, IoT system are useful for associated construction facilities for environmental resources and public health protection [32, 44, 46, 85]. Therefore, geoinformation tools are getting more useful applying them properly within multidisciplinary fields for decision making and action plans to stakeholders with the proper use of digital image processing utilities [2, 4, 5, 6, 7, 10, 15, 16, 17, 18, 21, 25, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 44, 47, 50, 53, 54, 56, 57, 58, 59, 60, 63, 74, 75, 77, 79, 81, 82, 86, 87, 88, 89, 90, 91, 92, 93]. In this way, it can be useful for particular safe sustainable development facilities around green circular economy and sustainable health tourism at post COVID-19 pandemic era [32, 38, 71, 72, 73, 74, 76, 78, 81, 82, 83].

A modern know-how for environmental protection in order to be efficient could use proper ICTs, IoTs, multidisciplinary fields, smart engineering applications so as to mitigate risks that exist from particular landfill emissions [25, 51, 52, 61, 62, 64, 67, 70, 85, 86].

Proper efficient information communication technologies and internet of things, ICTs, IoTs are needed for better project management of landfill emissions and protection of relative facilities around ecological tourism, agricultural tourism, social community health care centers for all, integrated veterinary units, efficient sports construction facilities at post COVID-19 era. Landfill emissions as well as some waste water units that follow the operation of landfill designs include leachates and biogas production. The latter landfill emissions could be exploited properly following the right green designs for sustainable development, forest protection,and sports facilities, associated health tourism facilities. Proper digital image processing utilities, ICTs, e-infrastructures, IoTs could be used for an efficient project construction management of landfill emissions at several reclamation and development works for environmental protection, social cohesion after lock downs at post covid 19 era and public health protection from associated environmental hazards [32,45].

However, in addition to proper digital utilities are necessary for monitoring leachates production and proper treatment from particular landfill designs [28, 29, 30, 31, 34, 39, 40, 41, 42, 46].

Moreover, waste input material and following design principles are determining the landfill emissions. Carbon dioxide and methane are greenhouse gases provoking the climate change on our planet [20, 21, 23, 44, 71, 81]. Waste material properties and climate conditions vary among particular sites which set up the constraints for sustainable designs. The installation designs of proper gas collection pipe networks are necessary for associated risk mitigation that are essential to be realised as well as proper monitoring, maintenance of them in time should exist protecting public health [30, 31, 37, 38].

In this chapter, we are present landfill gas emissions in relation to temperature of biomass, pH from MACH experimental landfill [30, 31]. That experimental project has shown that pretreatment of waste that is sustainable minimizing the particular chemical threats to particular environmental resources, soil, water, air, and associated environmental resources protecting public health [29, 30, 31, 33, 34].

2. MATERIALS AND METHODS - LITERATURE REVIEW

Landfill emissions are produced in terms of leachate chemical index toxic characteristis like COD, TOC, in high concentrations for big landfills as well as landfill gases like VOC's [20,21,44,48,49]. Therefore, emerging environmental sanitary technologies are necessary applying properly particular digital utilities for proper exploitation of landfill emissions for sustainable development [16, 22, 32, 34, 42, 47].

New opportunities in creation of jobs are coming up based on landfill gases collection and exploitation for green transport electricity using electric cars or for heating at buildings, veterinary units, and other ones facilities supporting sustainability.

The potential impact of landfills on the environment is presented in Figure 1. However, proper utilities are needed to be used for better operations project management, environmental resources protection, social cohesion and sustainable development after lock downs with travels to ecological places, and public health protection [32, 82, 83]. Landfill designs should be efficient so as to exploit landfill emissions for better health tourism facilities, and other associated facility services to citizens at post COVID-19 pandemic era.

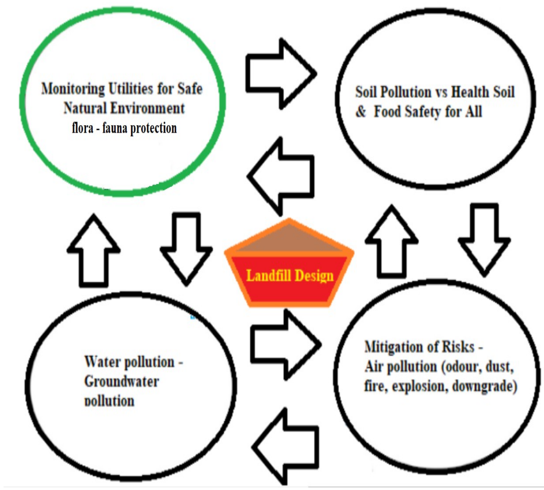

Figure 1. Potential impact of landfills on the environment

However, in figure 2 are presented monitoring locations in red color bullets next to landfills for environmental impact assessments utilising proper geoinformation tools, web utilities, image processing tools that could be used so as to identify topographic sites that are under particular environmental risks from leachates or landfill gases establishing associated simulation scenarios, and risk assessments for the right decision making, reclamation works, project management for sustainable tourism, public health protection [20, 30, 31, 33, 85, 86].

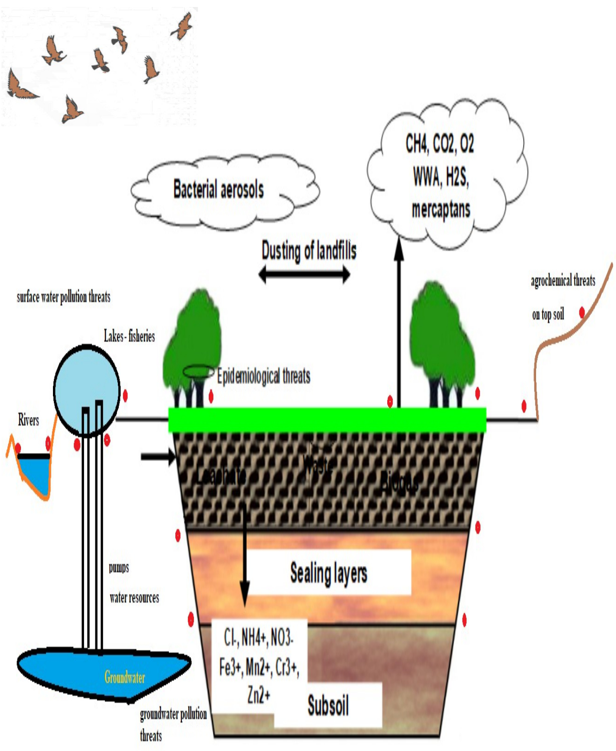

Figure 2. Sanitary drawing for monitoring locations next to landfills for environmental impact assessment of landfill emissions (red color bullets determine monitoring locations).

Robust computational tools are getting useful within fluid mechanics simulation scenarios – heat transfer modeling that could be used for better landfill designs based on given particular topographic, and waste input characteristics. Hence, proper software programming languages should be used utilizing properly digital image processing, gis, remote sensing, photogrammetry utilities that they can be applied for particular sustainable designs based on landfill sites' characteristics [8, 28]. Dynamic lining methods could be applied properly for useful construction management, BIMs, tools for sustainability and environmental health [41, 42, 43, 49, 71].

Useful digital image processing applications are necessary for the right identification of topographical characteristics for monitoring leachates treatment ponds, maintenance of such sites and decision making for that sites in extreme weather events like floods or fires so as to have alternative solutions to mitigate the associated risks, and to protect environmental resources and public health.

3. RESEARCH METHODOLOGY

Firstly, the project management process areas in landfill green chemistry need to be defined for an integrated sustainable landfill design for public health protection. These include the following stages:

- Chronical programming
- Working schedule and maintenance
- Safe logistics
- Agricultural constructions and landscape upgrade
- Simulate extreme weather scenarios
- Simulate extreme natural disaster scenarios based on particular topographical characteristics
- Decision making for integrated project management utilizing proper digital image processing tools
- Risk Assessment – Simulation and Management applying proper utilities,
- Use proper ICTs, IoTs, smart engineering applications
- Quantitative analysis for Project

Management

Useful utilities are necessary to be combined with dynamic numerical models for an integrated environmental protection and public health protection next to landfill sites. Proper biogas collection networks should exist as they are presented below, avoiding landfill gas migration, and mitigation of probable risks for public health protection.

However, a sustainable batch bioreactor design like MACH one has presented satisfied results for environmental protection [30, 31, 33, 34, 35]. Such sustainable designs could be useful to be linked with associated reclamation works within green circular social economy at post covid 19 pandemic era [14, 45]. In figures 3, 4, 5, 6 are presented the Mid Auchencarroch's, MACH's batch biorector characteristic emissions in terms of biomass temperature, pH and biogas production rates at four different cells.

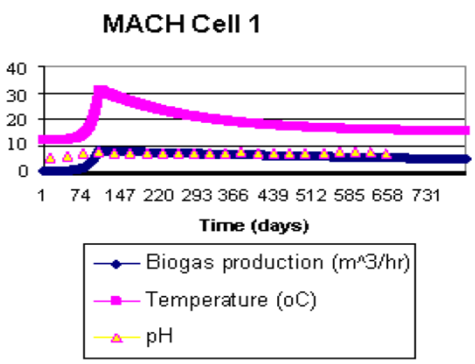

Figure 3. Biogas production and biodegradation characteristics at MACH's cell 1. Source: [31]

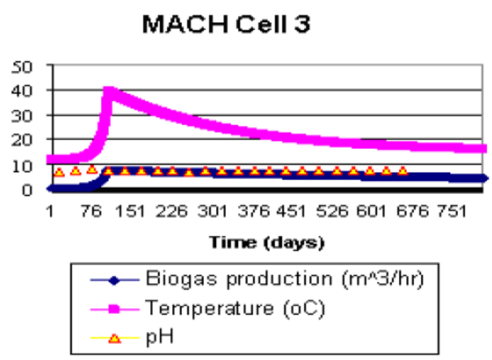

Figure 5. Biogas production and biodegradation characteristics at MACH's cell 3. Source: [31]

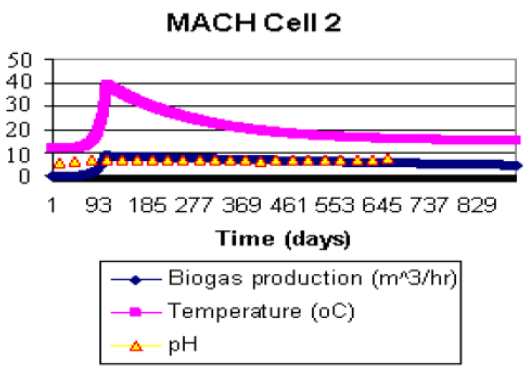

Figure 4. Biogas production and biodegradation characteristics at MACH's cell 2. Source: [31]

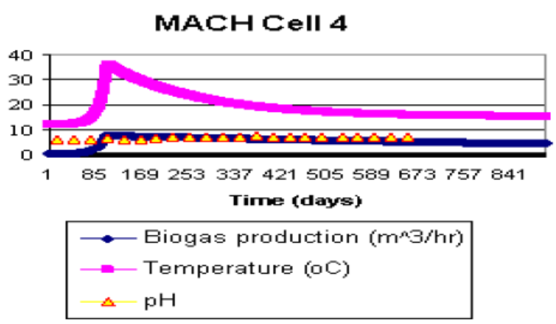

Figure 6. Biogas production and biodegradation characteristics at MACH's cell 4. Source: [31]

Based on figures 3, 4, 5, 6 the presented results, show great biodegradation of the waste mass and the produced landfill emissios in short time period.

Spatial characteristic constraints should be taken into account in related sustainable designs in orger to mitigate the associated risks from batch bioreactors [44, 84].

Furtermore, the proper use of a digital image processing utility is presented below for simulation scenarios, risk assessment, decision making and reclamation works. Satellite data could be used from the particular e-clouds (ie. SPOT, Landsat, IRS-1B etc.) making the right decision making for reclamation works and upgrade of landscapes of old landfills creating and supporting new jobs for the good of the community. Such projects are necessary so as to have clean environments mitigating the associated risks to human, flora and fauna. Modern computer aided mapping software and proper digital image processing could be utilized for the development of a photomosaic based on edited orthophotomaps [30, 37, 84].

A hybrid image processing could be used utilising properly collected digital surveying data and applying proper digital image processing and photogrammetric principles [30, 84, 89]:

- Create accurate geometric details on digital images with geo-references
- Apply mean signal processing filter in order to smooth noise
- Determine region boundary using the Boundary-Following Algorithm
- Accurate measurements of distances taking into account given mapping data points
- Use properly numerical data results combining in relation to identification of optical tresholds of hazards in order to create treshold maps taking protection measures at particular land uses protecting flora and fauna (use euclidean; structural; chess distance).
- Apply median signal processing filter in order to smooth noise.
- Apply non-linear signal processing transformations for digital image contrast control
- Apply methods to extract image characteristics based on Otsu, Reddi , Kapur method
- Apply first order derivatives or second order partial differential equations in order to determine pinnacles, use Kirsch transformations for brightness control, Marr and Hildreth ones, log filter, zero bestriding method and variation control for pinnacles detection respectively, apply Laplace differential equation filters for sharpness in edge detection and digital proper geo-references

Taking into account the above digital image processing utility principles, they can be processed properly several remote sensing images so as to extract useful risk assessment results of landfill emissions management including particular maintenance projects. Robust lining methods could be applied properly taking into account associated surveying data and digital photogrammetric resources for the right decision making for reclamation works or in emergencies.

Moreover, additional maintenance is needed for monitoring networks in-situ at main landfill area as well as across its boundaries. In this way could be protected the top soil form landfill emissions as well as associated flora, fauna, environmental resources.

The mapping out of an efficient monitoring scheme should take place on top soil and in depth with frequent sampling data of landfill emissions that should be taken in time for risk assessment and right decision making, reclamation works for soil protection and food security [28, 32, 34].

Furthermore, proper pumping networks should operate for the produced leachates and gases from the biomass not only to protect public health but also to collect them for further treatment enhancing green circular economy [23,28,32,34,35,44]. Applied dynamic computational tools are becoming necessary combining their results with web geoinformation tools, smart engineering utilities, photogrammetric utilities, ICTs, IoTs, and spatial information systems' applications for the right monitoring, achieving public environmental health protection, safe sports tourism facilities, sustainable smart cities within green social circular economy [85, 86].

A useful sanitary drawing for the right operations, monitoring locations of soil – associated environmental resources so as to protect them from biogas migration or leachates leakage is presented in Figure 6. In this way are protected agricultural land uses, associate flora – fauna resources next to landfill boundaries. In figure 6, the red bullets show where the monitoring points should be located.

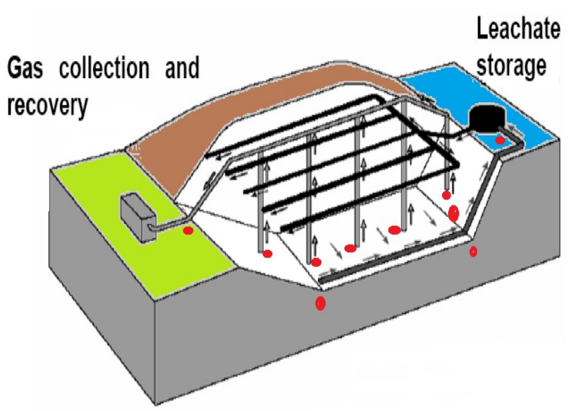

Figure 6. Sanitary drawing for monitoring schemes at landfills protecting flora and fauna resources next to landfill boundaries, (red color bullets determine the monitoring points).

Useful utilities are necessary to support the operation of sustainable landfill designs, where landfill emissions could be exploited at particular sustainable development projects i.e. qualitative safe food to veterinary units, innovative construction designs to support ecological health tourism infrastructures and integrated clean technologies.

The next activities have to bear in mind so as to achieve sustainable development

- Installation of monitoring boreholes – data collections and analysis
- Development of goals and objectives
- Clarification and diagnosis
- Identification of alternative solutions
- Planning of alternatives
- Recommendations of actions and evaluations
- Development of an implementation programming
- Monitoring and surveillance in time
- Apply proper sanitation measures due to post covid 19 pandemic era
- Adopt the proper dynamic models, ICTs, IoTs, system analysis tools, right modules to provide solutions

In figure 7 are presented the results of proper modules using digital image processing principles for the simulation, decision making, monitoring, and project construction management of landfill emissions, leachates. Such results could be combined with dynamic numerical results for the protection of soil materials, associated flora, fauna resources as well as public health protection. Proper fluid mechanics principles could be used for the protection of water resources from particular leachates concentrations taking the right measures in time as presented below.

Figure 7. Apply right digital image processing utilities for detection of characteristic surveying data in simulation scenarios, risk assessments, project management and decision making [30].

Moreover, figure 8 shows the overall research methodology so as to mitigate particular risks from environmental resources and to protect environmental resources - public health.

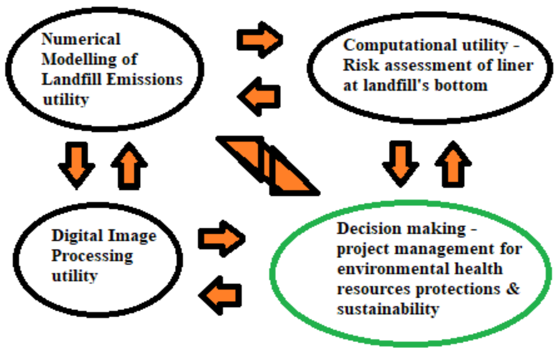

Figure 8. Proper geoinformation utilities could be used for decision making – project construction management of landfill emissions for public health protection and sustainability.

According to Figure 8, the right utilities could be selected for risk assessments, simulation scenarios and decision making at landfill's project construction management for sustainable development. For complicate environmental systems an integrated geo-information utility could be developed taking into account the particular autonomous utilities as modules into the total operation. Proper ICTs, IoTs and associated web utilities could be used for the right decision making at complex topographies and environmental systems.

Furthermore, based on the above research methodology a useful computational risk assessment tool for environmental resources protection is presented below that could be combined with the digital image processing one or other associated ones and associated collected field data for an integrated environmental health protection [33].

The use of field data, utilization of collected data into digital databases and lining properly monitoring networks are necessary for the risk assessment of liner systems at bottom of landfills and right control of landfill emissions. The development of risk assessment numerical models is useful for further analysis of taking any relative security measures and reclamation works.

Furthermore, except the above evaluation combinations of landfill emission's behavior should be taken into account an additional spatial risk assessment of a probable increased leachates' head flood, following a proper confrontation methodology so as to avoid any particular chemical fluxes on given topographies from the waste mass to the surrounded environment.

However, in the case migration has been made due to a flood extreme event of a sudden increased leachates head then the proper application of numerical analysis for the solution of advection and diffusion phenomena should be made for the proper lining of spatial management works for any migrated landfill emissions. Any available chemical field data should be collected in this case, which are necessary so as to be combined with any other available numerical models, Geographic Information Systems and mapping monitoring data on a given landfill topography taking into account proper reclamation, bioremediation projects.

Moreover, in order to avoid any migration of leachate toxic chemical discharges to the environment, due to a high leachate flood head, the determination of probable leachate leakage underneath liner's layers should be made after the right application of geo-membrane and clay depth on the ground surface, respectively. The necessary spatial associated risk assessment parameters, which should be calculated and to be applied properly on the bottom of a landfill topography or collateral to the particular landfill boundary ground morphologies are the next:

- the hydraulic conductivity of chemical fluxes in porous media;
- the annual leachate chemical discharge (L/m2)
- the arrival time of pollutant's concentration front
- the pollutant transfer,
- the advection and diffusion (years).

Assuming that the leachate chemical flood head is 10 m, after the drainage system collapse due to a big sudden flood event and that the total liner layer is completed by a clay layer 1 m depth and a geo-membrane with 1.5 mm thickness, then the vertical hydraulic load inclination will be

$$i = \frac{\Delta h}{\Delta L} = \frac{h_1 - h_2}{d_{clay}} = \frac{11m}{1m} = 11$$

the hydraulic pressure on the upstream surface of the liner layer will be

$$h_1 = P_{w1} / \gamma_w + z_1 = 10m + 1m = 11m$$

the hydraulic pressure on the downstream surface of the liner layer will be

$$h_2 = P_{w2} / \gamma_w + z_2 = 0m + 0m = 0m$$

measuring the z depth from the downstream and assuming atmospheric pressure there (P_{w2} = 0); taking hydraulic conductivity for the clay material 10 $^{-9}$ m/s and for the geo-membrane 10 $^{-13}$ m/s, then the vertical hydraulic conductivity for the liner material will be

$$K_{liner} = \frac{\sum d_i}{\sum \frac{d_i}{K_i}} = \frac{d_{clay} + d_g}{\frac{d_{clay}}{K_{clay}} + \frac{d_g}{K_g}} = \frac{100cm + 0.15cm}{\frac{100cm}{10^{-7}\frac{cm}{s}} + \frac{0.15}{10^{-11}\frac{cm}{s}}} = 6.3 * 10^{-9}\frac{cm}{s}$$

and the respective leachate chemical discharges will be the next for the clay and the liner respectively:

$$Q_{clay} = K_{clay} iA = 10^{-9}\frac{m}{s} * 11m * 1m^2 = 11 * 10^{-9}\frac{m^3}{s} = 347\frac{lt}{year},$$

$$Q_{liner} = K_{liner} * i * A = 6.3 * 10^{-11}\frac{m}{s} * 11m * 1m^2 = 6.93 * 10^{-10}\frac{m^3}{s} = 22\frac{lt}{year},$$

assuming that for the examining hydraulic inclinations is valid that i (geo-membrane) = i (clay).

The next risk assessment step should be the determination of the needed time for an investigated leachate migrated concentration, which will pass the liner layer. Below is taken place a relative security investigation risk assessment, assuming a probable chemical leachate C concentration of an examining organic acid migrated concentration (*i.e.* iso-valeric acid, acetic acid *etc.*) equal to C = 0.001 Co, where Co is the initial examining chemical concentration as it was measured before its passing through the liner layer and its migration outside from the landfill boundaries.

The latter examining spatial risk assessment problem for the investigating C chemical concentration plume flux is described by the following equation 1, with its analytical solution as it is described in equation 2. Similar scenarios should be followed for particular leachates heads based on characteristic rheological data and proper flood hydrological risk analysis on a topography [9].

$$\frac{\partial C}{\partial t} = \left(\frac{D}{n}\right)\frac{\partial^2 C}{\partial x^2} - \left(\frac{v}{n}\right)\frac{\partial C}{\partial x} \quad (1)$$

The proper solution of equation 1 it yields equation 2.

$$C(x,t) = \frac{C_o}{2}\left\{\operatorname{erfc}\left(\frac{x - \frac{\bar{v}}{n}t}{2\sqrt{\frac{D}{n}t}}\right) + \exp\left(\frac{\bar{v}}{D}x\right) * \operatorname{erfc}\left(\frac{x + \frac{\bar{v}}{n}t}{2\sqrt{\frac{D}{n}t}}\right)\right\} \quad (2)$$

Where, for distance x=0, chemical concentration C equals to the initial one Co, C = Co

$$\operatorname{erfz}(z) \equiv 1 - \operatorname{erf}(z) = 1 - \frac{2}{\sqrt{\pi}}\sum_{n=0}^{\infty}\frac{(-1)^n z^{2n+1}}{n!(2n+1)}$$

D = diffusion coefficient, is assumed that D = 32 cm2/year; n porosity of the porous medium, is assumed that nclay = 0.4; ngeomembrane = 0.02; ν = mean velocity of the investigating C chemical concentration; t = time to reach a defined spatial threshold the investigating C chemical concentration (years); for the clay layer there will be

$$\bar{v} = 2.75 * 10^{-6} cm/s = 86.7 cm/yr, \quad \frac{\bar{v}x}{D} = \frac{86.7 * 100}{32} = 271$$

for the liner layer there will be

$$\bar{v} = \frac{6.9 * 10^{-8} cm/s}{0.4} = 5.44 cm/yr, \quad \frac{\bar{v}x}{D} = \frac{5.44 * 100}{32} = 17$$

According to the above, taking for C = 0.001 * 415 = 415 μg/L iso-valeric acid concentration and applying the above data there will be for the clay layer only t =0.76 years (*ca.* 9 months) or for the total liner layer t = 6.7 years, where t is the time to reach the investigating C chemical concentration to the bottom of the examining layer depth, either it is only the clay layer or the total liner layer for both the clay one and geo-membrane one.

However, does not exist the installation of the right drainage security system underneath the landfill bottom collecting for treatment of toxic leachates, then a probable accumulation of several toxic concentrations will be accumulated at landfill bottom. In that way there will exist probable risk to associated receptors. In such latter case right sustainable design is necessary so as to mitigate associated risks [30].

Moreover, a computational inspection for probable hazards from leachate particular concentrations should exist which could operate as a risk assessment tool mitigating associated risks to receptors, (*i.e.* COD, TOC, other organic acids' concentrations, heavy metals at top soils, *etc.*). Therefore, the proper mapping out of a right dense drainage pipe network system at landfill bottom should be installed supported by smart engineering applications in monitoring schemes so as to identify probable leakage of leachates to the environment.

Moreover, a dense monitoring network of boreholes should exist next to landfill boundaries so as to mitigate risks and taking right measures avoiding probable further collapse of the liner drainage system due to extreme flood events in combination to other simultaneous natural disasters i.e. earthquake. The relative engineering regulations as well as ISO standards should be followed properly in time so as to mitigate risks.

The above presented utilities should be applied properly for the particular chemical hazards that have been found at landfills' bottom liner drainage systems. Efficient designs and emerging environmental technologies are necessary so as to protect particular infrastructures like sustainable health tourism facilities; agri-tourism ones; veterinary units; health soil; safe sports physical activities and other ones that promote creation of new jobs; associated social activities - social cohesion after lock downs at post COVID-19 pandemic era.

4. CONCLUSIONS

According to the present experimental field data of Mid Auchencarroch (MACH) experimental field data a very good organic depletion presented cell 1 and 3, minimizing any associated environmental risks in short time period. It was clear that the co-disposal with inert material is sustainable as well as the pretreatment by wet pulverization since the recirculation of leachate expedite the waste biodegradation.

All the examining chemical concentrations and pH values present great reduction and nearly neutral environment respectively (pH = 7), in the first 12 months, showing that MACH site was stabilized successfully in short time period. Hence, anaerobic batch landfill bioreactors could be used as efficient sustainable landfill sequential.

However, an efficient landfill emissions' contamination control could be achieved by a proper installation of a landfill bottom drainage system. A dense lining of landfill emissions' monitoring network and probable bioremediation works next to landfill boundaries should take place based on above presented utilities taking into account particular landfill topographical characteristics and waste input materials.

Therefore, following properly all the above there will be an efficient minimization of any associated risks and any related environmental impacts next to landfill topographies.

The results of this study are useful for effective web utilities, IoTs, simulation scenaros, risk assessment, decision making and reclamation works so as to protect particular soil – environmental resources from hazardous landfill emissions. The presented utilities will be useful t for soil health, food safety, safe sports physical activities, safe veterinary units, medical tourism facilities, safe ecological health facilities, agri-tourism, and forest infrastructures for medical sports. In this way could be achieved a sustainable development in a green circular social economy.

Future sustainable designs should include digital image processing utilities combined with computational fluid mechanics utilities mitigating associated risks to the environmental resources, creating safe unique travel destinations and associated services within medical tourism at post COVID-19 pandemic era.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest between them.

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