U.S.E.P.A. Docket ID No. EPA-HQ-RCRA-2015-0354 Lecce (Italy) 23/04/2019

"Revisions to the Criteria for Municipal Solid Waste Landfills to Address Advances in Liquids Management" and , toward a new sustainable process engineered landfill

LeMa Consulting is providing public comments on the following questions.

U.S.E.P.A. is considering whether to propose revisions to the criteria for Municipal Solid Waste Landfills (MSWLFs) to support advances in effective liquids management. To this end, EPA is seeking information relating to: Removing the prohibition on the addition of bulk liquids to MSWLFs; defining a particular class of MSWLF units (i.e., bioreactor landfill units) to operate with increased moisture content.

Summary

Question(13) *In addition to the standard bioreactor landfill unit infrastructure and practices, are there any bundled engineering practices (*e.g., *complimentary requirements for leachate recirculation, LFG collection, and leak detection) that landfills operating bioreactor landfill units are likely to invest in? What are the additional or complementary benefits or risks of these investments?*

The national and international leadeship of U.S.E.P.A. can lead the design of a new kind of sustainable landfill. A new, "process based approach" is required.

Recent R&D Projects

LeMa, in the period 2014-2017, thanks to financial contribute of Ecofer Landfill (Rome-Italy), has developed a R&D bioreactor landfill project "BioLand". The objective of BioLand project has been the development of alternative management strategies and processes in the direction of sustainability of landfill plants.

Ecofer Ambiente S.r.l. operates an uncommon car-fluff mono-material landfill. The composition of waste stored in Ecofer landfill is mainly plastics. However there is persistent production of biogas, which shows phenomena of anaerobic degradation. This constitutes ipso-facto an important scientific evidence in terms of the development of knowledge regarding the degradability of plastic wastes.

The International regulation framework on landfill is based on a containment strategies ("dry-tomb"). Now containment strategy implemented at landfills have created timescales of at least centuries before landfill will reach a point where no active management is needed ("completion point").

The emerging challenge is oriented to developing a new "sustainable landfill" with a process based approach, and specifically, to influence landfill processes in order to achieve an environmental equilibrium (completion or final storage quality) within acceptable timeframe. State of the art of scientific literature has highlighted a proliferation of deterministic aerobic and anaerobic digestion models, often too complex for engineering applications both for the number of equations and parameters - not experimentally evaluable - and with high computational overload non compatible with real-time industrial applications. The limits of worldwide research on "sustainable landfill" result from a "research driven approach", finalized to specific scientific topics in the timeframe of a shortly research project.

Conversely, landfill dynamics is characterized by high "time constants" of the order of some decades. Landfill is characterized by **strong dynamics, evolutionary processes, emerging behaviours and uncertainties**. Unforeseen conditions may arise during the life of the plant, but at the same time, **evolutionary and adaptive processes toward bio-stabilization emerged as endogenous property of landfill.** The partial controllability of landfill requires advanced computation and communication technologies to make system "cognitive". A first-order deterministic model was developed, based on material and energy balances, to overcome the limitation of existing models. The model is characterized by necessary and sufficient equations, parameters and variables and so it can be considered a constitutive model of a bioreactor landfill. The limited number of equations is compatible with engineering real-time simulation and control. The model allows to overcome simplified approaches to kinetics (k) and is necessary for site-specific process control.

The BioLand Project has highlighted the technological frontier in bioreactor landfill summarized by the unavability of industry-technological platform for predictive modelling and operational control of a so complex dynamic bioreactor.
In 2018, we invested in a newco to industrialize a cyber-pysical-system (CPS) primarily oriented to landfill bioreactor modelling and control.

Investments in new predictive ("digital twin") and control technologies (C.P.S.) will allow to combine environmental, social and economic benefits.

The technical leadership of U.S.E.P.A. in the direction of a sustainable blue-economy will bring huge benefits to innovation of landfill sector.

B. Questions on Characteristics of Bioreactor Landfill Units and Wet Landfill Units

Question B(1): *If EPA should adopt a definition of a new RCRA class of MSWLFs outside of RD&D permits, is the qualitative definition in Section VII, i.e., that a bioreactor landfill unit is defined by the intentional addition of liquids for any purpose other than cleaning, maintenance, and wetting of daily cover, an appropriate to definition? Or is a quantitative definition based on moisture content more appropriate?*

A unit operation such as a bioreactor may be defined based on process scope rather than on specific process parameters. A new conceptual definition is necessary based on the following considerations:

- A Bioreactor Unit operation is a pre-treatment unit although realized within the same storage volume of the landfill.
- A bioreactor unit is not a "Landfill". It may be authorized as a pre-treatment of waste inside a landfill site.
- **The Scope and definition** of a waste bioreactor unit operation is **"a bio-reaction based waste treatment unit to accomplish a specified degree of stabilization(Final storage quality) within a specified time frame"**
- The addition of liquids is necessarly subordinate to process scope and a specification of a minimal quantity is a non sense, in respect to process scope.
- Achieving process scope within an accellerated time frame must be a responsbility of the operator.

So we think that a bioreactor unit may be standardized based on specification of a **"final storage quality" or "degree of final stabilization"** which the operator must achieve within a auto-declared time-frame.

Question B (2) *If EPA should adopt a quantitative definition of a bioreactor landfill unit based on moisture content, what is the appropriate threshold for moisture content?* **Question B (3)** *Are there factors other than moisture content that should be used to define a bioreactor landfill unit in a quantitative manner?*

Moixture content is one of the process parameters which the operator must evaluate in a **preliminary process design study**, based on site selection, waste composition forecast, etc. The process dessign study must consider waste fractions (buffer composition, mechanical resistence, hydraulic permeability), water addition is based on water reactive balances.

Question B (4) *Should EPA include the use of leachate recirculation, run-on and run-off systems, and alternative cover designs in any new definition of a bioreactor landfill unit or wet landfill unit?*

Bioreactor pretreatment unit require a recirculation system, but there is no needs of particular specifications with respect to dry-tomb. The operator must design and operate the recirculation system to guarantee himself the operational capability of the processing unit.

Question B (5) *If EPA should determine that it is more appropriate to define and regulate wet landfill units instead of bioreactor landfill units, what factors should be considered in such a definition?*

LeMa Consulting S.r.l.
4 Giovanni Boccaccio St.
Lecce 73100 – Italy
Phone: +39 832 498023 • Fax: +39 832 575049
www.lemaconsulting.it • lema@lemaconsulting.it
REA LE267772 P.IVA 04115840755

Wet Landfill ! Why ? which is the environmental and process scope of a wet landfill ?

C. Questions on Operations and Post-Closure Care

Question C(4) *What design and operating changes, if any, should be considered to manage accelerated waste settlement in bioreactor landfill units and minimize waste instability issues?*

Bioreactor closure can be done after the initial settlment period. The **"Executive Process design study"** must consider composition and mass fraction to accomplish a mechanical stability a the end of the initial settlment. During bioreactor operation the operator may replace damaged biogas wells if necessary, etc.

Question C(5) *Should the prospect of increased leachate and accelerated LFG generation require that a Professional Engineer certify that any or all MSWLF components and subsystems (e.g., leachate collection and storage, LFG collection and control) be designed properly to handle the increased demands at a bioreactor landfill unit or wet landfill unit?*

Question C(7) *If the variances contained in the current RD&D rule were to be made allowable outside of RD&D permits (see Section II), what additional performance and prescriptive standards, if any, would be necessary to demonstrate protection of human health and the environment?*

A Certification by a professional engineer can ensure structural and mechanical conformity, but the final process scope is achivable by an integration of:

- **Initial Process design (Landfill Authorization):** in the initial phase waste composition is estimated based on incoming waste forecasts and the influence of process parameters estimated based on operator experience;
- **Detailed Process Design (Bioreactor closure):** at the closure time, during wells drilling is possibile to realize a complete characterization of solid waste fractions, eluitions tests, biodegradation tests, and to proceed with a executive process study.
- **Bioreactor processing and control:** based on the process study the operator may implement a "digital-twin" (a dynamic model of the bioreactor and a instrumented control system for process control and environmental monitoring purpose. A new technology support is necessary.

D. Questions on Potential Risks

Question D(1): *Are there current scientific studies or other data available pertaining to the impact of moisture content on the frequency and rate of leachate leakage or other types of environmental releases from landfills?*

NO. A Landfill realized in accordance with the actual containment strategy (EPA '91, or UE landfill Directive.) has enough containment safety-levels.

Question D(2) *Is there evidence of increased groundwater contamination from bioreactor landfill units as compared to dry-tomb landfill units?*

No. At the contrary! In the short period dry-tomb may appear characterized by a reduced risk, but in the overall life, dry-tomb will generate an higher risk. A site-specific risk analysis realized by LeMa in 2008 with support of IWEM and IWAIR have demonstrated that in the long term (when containment and barriers will be damaged >60-80 years dry tomb is not stabilized) the environmental risk is very high!

Question D(3) *Should EPA remove or modify the bulk liquids restriction in 40 CFR 258.28? For example, should the addition of liquids be limited to off-specification consumable liquids or be open to all non-hazardous liquid waste?*

The main process variable for waste stabilization is water. But available liquids are very limited compared to the needs. So every liquid coming from precipitations, external waste waters, etc. are necessary to accomplish process scope. Quantity and quality must be determined by the operator on a real-time basis.

Question D(5) *Are there restrictions or conditions on liquid waste acceptance that EPA should consider? For example, are there any properties (*e.g., *pH, ionic strength, biological activity) of specific kinds of liquid waste (*e.g., *sewage sludge, grey water, animal feedlot waste) that may exacerbate releases from co-managed wastes and should be considered for possible restrictions on liquid waste acceptance? Are there any properties of the residual solids from these liquids that may pose risk when managed at the lower water content within the landfill?*

Restriction on specific liquid waste acceptance may results in operational trouble. The prescription may regard the omogeneity of the bulk waste inside the reactor rather than incoming flux.. A good practice is to mix sludge with other waste to obtain a buffered solid waste composition. The scope is to realize a solid buffered food substratum for living organism (bacteria, etc.)

Question(1) *The EPA requests information pertaining to the costs or estimated costs of construction, operation, closure, and post-closure care of bioreactor landfill units and wet landfill units. How do these costs compare with the costs associated with dry-tomb MSWLFs?*

Investment Costs of bioreactor is comparable with dry-tomb. Economic advantages arise from reduction of costs associated with leachate external treatments, reduction of post-closure period.

Question(4) *What are the benefits associated with increased LFG generation and capture?*

A pro-active and managed LFG production imply a reduction LFG dispersion and more LFG to energy recovery.

Question(7) *How does managing organic waste in bioreactor landfill units compare, in terms of the cost, cost savings and benefits, to managing segregated organic wastes through composting or anaerobic digestion?*

Managing segregated waste through composting or dedicated anaerobic digestion plant imply costs of investment, transport, collection, and moreover this plants are very difficult to optimize and to run.

Question(15) *Has the temporary status of permits under the RD&D rule discouraged any owner/operators from otherwise investing in bioreactor landfill units?*

Yes! From Pohland study ('72) EPA('91), is known that a dry-tomb approach imply a perpetual care of landfill and costs for citizens will be ∞. Moreover, this has determined the block of industrial investments not allowing to acquire the behavioral models of biological reactions at industrial scale.

Sincerely
Sebastiano Martignano, CEO Lema Consulting Srl