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Enrique ORCHE, María Pilar AMARÉ
School of Mines. Universidad de Vigo. Spain

USE OF ABANDONED QUARRIES AS URBAN WASTE DUMPSITES IN SPAIN

Summary. Abandoned quarries are difficult to restore from an environmental point of view. Nevertheless, one of the uses that could be given to such quarries, in present times of exorbitant land prices, is that of an urban waste dumpsite, with which we are able to solve two problems: That of restoring a degraded environment and that of controlled elimination of domestic refuse. The present paper describes a specifically designed methodology for studying such a problem by proposing a program of linked actions which when combined with mining and environmental techniques.

WYKORZYSTANIE DAWNYCH WYSYPISK MIEJSKICH W HISZPANII

Streszczenie. Z punktu widzenia środowiska naturalnego rekultywacja dawnych wysypisk miejskich jest bardzo trudna. Niemniej jednak, w obecnej sytuacji wygórowanych cen na ziemię, zaproponowano metodę, by przez rekultywację zbędnego wysypiska miejskiego rozwiązywać dwa problemy. Jednym z nich jest przywrócenie pierwotnego stanu zdegradowanemu otoczeniu oraz kontrolowana eliminacja elementów szczególnie niebezpiecznych. W artykule opisano szczegółowo proponowaną metodologię rozwiązywania tych problemów przez projektowanie łączonych działań górnictwa i technik ochrony środowiska.

1. Introduction

Human consumption habits give rise to a constantly increasing amount of Municipal Solid Wastes (MSW) which the natural environment is unable to assimilate over its natural cycle.

Incineration of the MSW is one of the many official solutions to the problem of refuse production from now on. Nevertheless, this solution is not liked by many municipalities who would prefer to see the problem tackled via other means of MSW elimination. What is quite clear from the way things stand right now is that as long as there is no straightforward agreement for systematic treatment of MSW, their stacking in dumpsites is one of the few options available at least in the short term.

One must bear in mind that there will always be some contaminant residue left over, irrespective of whether we opt for indiscriminate burning of MSW or for an exhaustive recovery of its components, which can only be eliminated at a dumpsite. Therefore, these waste tips would, in a greater or lesser measure, be viable for quite long periods of time.

The unpopularity of such a solution is quite obvious because people are ever increasingly becoming conscious of their right to live with a minimal but dignified quality of life, which is hard to accept especially when one has a dumpsite next door. On the other hand, there is also an increasing social demand to restore spaces that were degraded due to past industrial or mining activities and it is precisely in these situations that the use of quarries as dumpsites can be of great interest. Given society's refusal towards the implantation of new dumpsites, all towns which have abandoned mining cavities would have the possibility to exploit a space fit for waste storage at a much lower cost than that of conventional landfills, thereby also resolving an environmental problem.

Firstly, quarries with impermeable materials or those that are permeable but sealed adequately, are ideal spaces for siting MSW landfills, since these are sometimes located distant from population centres.

Secondly, their shape is mostly satisfactory for guaranteeing the stability of accumulated wastes.

A third advantage is that we are contributing to the regeneration of a degraded space after infilling and restoration operations are carried out.

Therefore, a study of the use of quarries as MSW dumpsites can be considered as one of the possible and valid alternative solutions available to incineration and recycling.

With this view in mind, the University of Vigo (Spain) financed a research project to develop a methodology to study the feasibility of abandoned quarries as MSW dumpsites, including the technical project. The said project was finished at the end of 1999 and is one of the pioneering projects in Spain, because dumping domestic waste in abandoned quarries was at best, a practice undertaken with a reduced technical control, thereby at times giving rise to

even bigger problems than the one they were trying to resolve. The present paper is a brief résumé of the aforementioned project.

2. General overview of the project

It is frequently the case when the Directives for Residues, establish a list of siting criteria for dumpsites, which can be summed up as follows:

- Demographic Study
- Analysis and Statistical Forecasting of the volume of residues generated
- Location of demographic poles
- Location of waste generating poles
- Definition of waste management areas following the above criteria.

Based on the above information, it is common to define possible future dumpsites with the sole criterion of maximum distance concentric circles from the waste generation poles. It is only at this moment in time, that geological, geotechnical, hydrological and infrastructure analysis are done at a secondary level within the previously selected sites.

This procedure has been frequently found to be unable to adequately resolve the dumpsite location problem and therefore the need for a revised methodology that consists of:

- Search for an adequate dumping site
- Verify the suitability of the site for receiving wastes
- Development of the exploitation project (including that of waste generating poles which it could attend to).

The sites searched in this case would correspond to abandoned quarries although it would also be wise to look at all other working quarries, which due to their huge dimensions could permit their use as landfill sites in the parts that have already been exploited.

The suitability to receive wastes implies carrying out a series of studies to guarantee precise waste storage capacity, the impermeability of the site and the protection of the environment.

The study of waste generating poles which the landfill site could attend to, provides us with information such as volume, type & quality of wastes to be expected, which are fundamental data needed for developing the dumpsite project, which in itself would be the final stage of the process.

The present methodology is a novel application in Spain and no other similar case study has been known to date.

The almost reverse order structuration of the order of priorities set out in this study as compared to the traditional method has immediate economic repercussions, because it proposes decision making on certain sites which due to their past mining activity possess a dumping cavity of a considerable dimension, and which can be accessed via appropriate infrastructures, which as a new works site can be very expensive.

Our philosophy starts by contradicting normal customs in environmental engineering, and therefore considers the cavity formed as a consequence of mining activities to be a rather valuable infrastructure, that is immediately available together with other advantages such as geological and geotechnical information, direct access to the base materials at the landfill site or access to sealing, ripping and stacking materials at slag heaps.

From an environmental point of view, the above is in stark contrast to siting a landfill site on new virgin land or even the literal excavation of a sufficiently big enough cavity, which implies the movement of a huge amount of earth which for all practical purposes is but useless.

The most favourable mining sites for conversion into waste dumpsites are those of clay, gypsum, ornamental granite, slate and granite aggregates, gneiss & construction porphyry.

All of the above are leakproof materials since they lack primary permeability and some of them additionally do not even show fractures.

3. List of quarries that can be used as msw dumpsites

The inventory tries to list the availability of suitable abandoned mine sites for use as MSW dumpsites. Therefore, this would be the first step to be taken after a management decision, to use such spaces as dumpsites.

Not all of the abandoned quarries can be potentially used since they would have to comply with certain preliminary requisites of the legislation in force and additionally would have to meet a minimum of technical conditions. Thus, the inventory can be considered as a first stage to eliminate certain possible sites for non-compliance with the minimum requisites. Such minimum requisites have to be outlined for each case although we do know that common criteria must be applied to all future landfill sites such as for example the nature of

the bedrock on which they would be sited, the proximity to urban areas or the minimum cavity space needed in the quarry.

The basic information on abandoned quarries can be obtained from the offices of the Mining Administration. It is here that one can consult registry books in which one can find the principal characteristics of the abandoned quarries and from where one can obtain verbal customised information on each of the quarries. Therefore, this first data helps us make a primary selection based on fulfilment of one or many minimum criteria.

All data collected must be stored in a homogeneous manner, for which it is customary to keep an individual file for each quarry and updating it with all information obtained.

The next step would be the selection of one of these areas to do a dumpsite operation project, whose details are as follows.

4. Methodology for suitability study of dumpsite and the exploitation project

4.1. Introduction

The methodology for the implantation of a dumpsite is well known even though there are many construction and operational projects which lack a highly important technical content. In fact, only certain specific dumpsite problems are frequently looked at while other parameters are mentioned superficially or are evaded altogether.

The novelty of the present study is that it establishes a complete methodology to get good use out of the abandoned quarries as MSW landfill sites, not only by paying attention to well known parameters but also by looking at those parameters which are systematically ignored in implantation projects. These correspond basically to the mining components of the study.

One should not forget that dumping, loading and urban waste treatment processes are similar to those for mineral substances. This fact is systematically ignored in Spain in spite of the evident similarities between MSW dumpsites and mining waste heaps, thereby leaving the drafting of studies and the construction and the operation of the landfill site, in the hands of personnel who are rarely competent in mining techniques.

Although the work sequence proposed in this paper has been mentioned in some of the recent specialised journals, it has not been developed sufficiently in none of them. In as far as study methods for the different parts of the project, some authors have suggested on specific

aspects based on normal practices or on existing legislation both at the national and international levels.

The technical cum economic studies index that every project must contain, depending on technical complexity and environmental guarantees, is as follows:

1. Site selection
2. Environmental impact study
3. Characterisation of the quarry and its surroundings
   - Administrative situation
   - Climate
   - Geology
   - Hydrogeology
   - Geotechnics
   - Infrastructure
4. MSW identification
5. Dumpsite design
6. Dumpsite volume determination
7. Production or Dumping parameters
8. Exploitation method
9. Machinery
10. Construction & exploitation of dumpsite
    - Dumpsite base conditions
    - Water protection
    - Base sealing
    - Temperature control
    - Production and control of leachates
    - Production and control of gases
    - Siting of wastes
    - Periodic controls
    - Protection
    - Work conditions
11. Facilities
12. Sealing and closure of dumpsite
13. Surface re-vegetation and alternative uses
14. Planning of dumping phases

15. Post-closure monitoring
16. Investment
17. Costs

When convenient, the quarry inventory could be included as an initial point in the index of activities to be undertaken. The methodology is exclusive to a dumpsite. Therefore, other items such as domestic refuse collection, transportation routes, optimisation of mobile collection equipment, etc. surely cannot be omitted from a general MSW management study, of which, the dumpsite is, but just the one part.

4.2. General methodology description

The general dumpsite study is made up of 17 fundamental concepts, some of which have been broken down into others, which due to their importance deserve a relevant treatment. It is recommendable that every study be sufficiently defined at least for the 17 aspects mentioned.

4.2.1. Site selection

The following criteria are generally used for site selection in the different studies:

- Criteria for zone exclusions
- Criteria for zone delimitation
- Criteria for zone suitability evaluation.

All site selection methods have a number of common points:

- A series of criteria are used
- The selection process is developed in stages, from a general to a specific direction.
- The criteria at any given moment have a specific weighting.
- The possible different sites are compared based on grades obtained.

When selecting one of many quarries, one should obviate certain parameters, which in spite of their huge importance, are normally unknown at the start of the selection process. These are parameters such as geological, geotechnical, hydrological or those of administrative location of the quarries. In such cases, it is preferable to base the selection on tangible and known data, although using apparently simple methods.

4.2.2. Environmental impact study

The environmental impact study of a project or action is an exercise for determining the consequences of such a project or action on the environment. This report is obligatory in Spain for siting dumpsites.

The environmental impact report must at least contain data on the project description and the activity, problems and objectives, size of dump site, its construction and equipment, use and management, final sealing and follow-up plans; an inventory, environmental interactions, their identification and impact evaluation; land use; land characteristics, subterranean and surface waters; air and noise; flora, fauna and ecosystems; the countryside, cultural history and geomorphology; social environment, the establishment of preventive and corrective measures and a program of environmental watch.

4.2.3. Characterisation of the quarry and its environment

This part tries to conveniently characterise the future landfill site and its immediate surroundings following different angles. It might be the case that after research into a certain characteristic, it so happens that the quarry is unsuitable for storing MSW under desired conditions. If this were to be the case, then one would reject this site and look for an alternative one.

In order to characterise a quarry, one must consider aspects such as administrative location, climatology, geology, hydrogeology, geotechnics and the presence of infrastructure.

4.2.4. MSW identification

The preparation, operation, lining of landfilled site cells and the final sealing, post-closure evolution of the dump site and use, would depend on the type of wastes to be deposited at the site. Therefore, there arises a need to understand the physico-chemical characteristics of the wastes. The present study considers that the quarries will be filled exclusively with MSW, which is defined by the Spanish legislation as "generated in homes, businesses, offices and service firms, as well as all those that are not classified as dangerous and which due to their nature or composition can be assimilated by those produced in the places or activities mentioned above". Accordingly, a) wastes from public roads, green areas, recreational areas and beaches, b) dead domestic animals, as well as furniture, personal items and abandoned vehicles, c) wastes from small scale construction jobs and home repairs, can also be considered as urban wastes.

The identification of MSW should provide for the evaluation of amount of waste generated around the quarry and an estimation of their behaviour, gases, leachates and possible compaction that might take place.

4.2.5. Dump site design

From a siting and final geometrical point of view, dump site design generally depends on aspects such as, initial quarry configuration, natural and environmental conditions, nature of the wastes, dumping process, auxiliary equipment, aesthetics, and destined use after its closure. In the case of quarries, their location and morphology; normally on slopes, principally warrants the topographic and vegetal restoration of the site and its maximal integration with the surroundings. Thus, the dump site must be located and designed in such a way that there is no hindrance whatsoever with this primary objective.

4.2.6. Dimensioning of landfill site

The dimensioning of the landfill site or estimation of its capacity, is the calculation of the volume covered by the quarry area and its topography, after the landfill site has been closed. Therefore, before calculating the volume, one has to define the final morphology of the quarry. The recommended dimensioning method is via horizontal sectioning because a great number of quarries have a level shape. The resulting volume must be occupied with compacted MSW and impermeable material used for base and landfill cell insulation, and the final sealing, for which the calculated capacity must be reduced by a factor proportional to that occupied by such cover and insulation materials. The calculated landfill site volume should be considered as just a preliminary estimation, since the real value would be determined by the compacting of the wastes which gives extra capacity to the landfill site.

4.2.7. Production

Upon knowing the landfill site capacity, one has to define a production program, i.e., volumes of MSW to be deposited in the quarry, in a definite time interval, which normally happens to be one year. In order to establish the production program, one can start with waste generation data from the surrounding municipalities which have agreed to use the quarry for their wastes, or as a first step by using average waste production of MSW per person/year which have been statistically established for the urban areas.

4.2.8. Exploitation Method

Although controlled dumping of wastes is an eminently practical method of wastes disposal, one must always bear in mind that landfill conditions over time would therefore produce circumstances that warrant or need modifications of some of the anticipated operational processes. The method should include:

- Bulk dumping
- Stacking of bales
- Moulding to final surface shape
- Access to the interior of the various dumping areas.

4.2.9. Machinery

The impact of this item on the cost budget reveals the importance of a correct selection of the mechanical means to be used. The waste compactor is a machine which both compacts and spreads waste over the landfill site. A wheel loader and a little caterpillar tractor can be used for auxiliary functions such as maintenance of internal roads, clearance of undergrowth, firebreaks, preparation of landfill base, etc.

4.2.10. Construction and exploitation of the dumpsite

This section must cover the different aspects involved with the construction and operation of the dumpsite, commencing with a previous knowledge of climatology, geology, hydrogeology, geotechnics, etc. of the quarry and of its surrounding environment. To this end, one has to successively determine soil conditions, protection of the surface and groundwater, lining of the landfill site base, wastes temperature control, production and control of leachates and gases, compacting of the wastes, periodic controls of the diverse important aspects related to dumpsite management, protection against diverse elements and the working conditions on the dumpsite.

4.2.11. Facilities

These would include all those facilities that would be needed for the correct functioning of the landfill site. Depending on each case, there would be a need for the construction of one or more facilities on many landfill sites, while existing facilities from the quarry could also be put to good use.

The location of the service area should be carefully selected since this area would remain active up to the end stages of the landfill site operation and some of the facilities located on this site will have to be functional for an even longer time.

The facilities to bear in mind are registry post at the landfill site entry, weighing scales, inspection area, dumping platform, accesses, waiting area, parking lot, vehicle-wash, office block, laboratory, workshop, water supply, electricity facilities, fuel supply and storage facilities, not forgetting the living quarters for personnel whenever needed.

4.2.12. Sealing and closure of dumpsite

The dumpsite must be sealed and closed once the urban refuse accumulation has terminated. The final covering of the dumpsite must not only prevent the entry of external water sources but also limit uncontrolled escape of gases, minimise risks of fire, and provide an adequate surface for the predetermined use of the space. The covering must be adverse weather proof and be resistant to water and wind based erosive forces, it must be stable against sinking, breakages, land slides, movement of people and machinery, and must also be resistant to breakages that could occur as a result of activity by living organisms, earthquakes, etc. The dumpsite base inclination must also be given preferential attention. The final dumpsite surfaces, both top and lateral slopes must be improved according to the following program:

- Checks of the platform, berms and slope inclination.
- Sealing of the final surfaces.
- Land treatment.
- Planting of species.

Once the entire dumpsite is sealed hermetically, one can then proceed to close the dump site and start the monitoring phase.

4.2.13. Surface revegetation and alternative uses

The dumpsite recovery operations must cover the following aspects:

- Dumpsite sealing and closure and the provision of safety conditions for dumped wastes, erosion control and environmentally impacting agents.
- Optimisation of landscape integration
- Utilisation of resulting land for appropriate future use.

At a general level, such land can be given different alternative uses such as reinstatement of the regional ecosystem, creation of development zones or the establishment of a different vegetal system.

4.2.14. Planning of dumping phases

A frequently forgotten aspect in dumpsite projects is planning, which can be defined as the space-time study of the infilling of the dumpsite with MSW until it acquires the final planned configuration. This planning must be recorded in the corresponding site plans such that these represent objective positions right from the start of the dumping operations up to the end of the quarry infilling.

4.2.15. Post-closure monitoring

Monitoring work, even in the long-term, is essential to ensure dump site control. Such work consists of soil protection, maintenance operations and even the substitution of the facilities when necessary. Any negative environmental impact should likewise be scrutinised. Measures should be taken to eliminate contamination or prevent its spreading whenever necessary. The monitoring phase starts with the closure of the dumpsite. This is when no further wastes are dumped, the top seal is already in place and the final site inspection has already been carried out.

4.2.16. Investments

Every dumpsite project must have an assessment of investments to be made both at the initial stage as well as at the recovery stage.

4.2.17. Costs

Knowledge of investments and costs is of key importance when undertaking any business. Therefore, one should know a detailed estimate of the same, expressed as cost per ton of MSW or annual MSW dumping cost.

Recenzent: prof. dr hab. inż. Bernard Drzęźla

Abstract

Abandoned quarries are difficult to restore from an environmental point of view and therefore constitute an ever increasing problem. Nevertheless, one of the uses that could be given to such quarries, in present times of exorbitant land prices, is that of an urban waste dumpsite, with which we are able to solve two problems: that of restoring a degraded environment and that of controlled elimination of domestic refuse. The present paper describes a specifically designed methodology for studying such a problem by proposing a program of linked actions which when combined with mining and environmental techniques, permits us to determine the suitability of a particular quarry for use as a dumpsite, via prior establishment of the nature and characterisation of such an area together with the plans for refuse dumping, dumpsite sealing, and monitoring and control of the same.