

Waste in caves and potholes - Risks and legal / administrative treatment in Greece

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ABSTRACT

The aim of this study is to present the extensive problem of illegal waste disposal within caves nationwide and to highlight the dangers and the legal - administrative and practical difficulties towards a solution. This issue has been a source of concern for the Independent Authority of the Greek Ombudsman, which has dealt with relevant cases in the past, bringing to light serious issues regarding both the effective management of solid waste and the inadequate protection of geoenvironment.

For several decades, many caves, and particularly potholes, which are located close to villages or near industrial plants and commercial systems, have become recipients of large amounts of waste. In many cases, municipal authorities are responsible for the dumping, which, unfortunately, has been a common phenomenon, especially before the enforcement of European rules on solid waste management. The effects vary and indicatively they involve groundwater pollution which constitutes a risk to residents' health, destruction of exceptional geological monuments that may also present archaeological - paleontological interest, extinction of protected endemic species and their habitats, death of cavers during their descent.

The legal and administrative problems posed are numerous and difficult to resolve. Firstly, due to the covert particularity of caves, most municipalities have not reported these discharges to the appropriate authorities, so as their purification to be planned. The recording of these cases is difficult and

can be accomplished only through integrated regional planning. Furthermore, the type as well as the origin of waste, according to legislation, determines responsible parties for the restoration.

The practical issues are mainly related to major restoration costs (due to the difficulty of the task) and to the difficulties services face as they are required to access the cave in order to determine the type of waste and the size of destruction, to conduct chemical analyses for water pollution etc. In all these cases, the lack of responsibilities distinction among civil services as well as the lack of qualified personnel in research and approach techniques is obvious.

1. INTRODUCTION

Karstification mainly occurs in carbonate rocks and is a result of water's erosive force. Carbonate rocks (limestone, dolomite etc) cover more than 35% of Greece surface (*Daskalaki P., Voudouris K., 2008; Ompetsanof I et al. 2004*). Greece has more than 10.000 documented caves due to karstic rocks, (*Hellenic Speleological Society, 2015*) although this is not the result of an integrated and official study. Speleogenesis occurs through a combination of geologic processes, such as dissolution, groundwater flow and rock collapse. Disturbance in these processes changes the fundamental characteristics of the cave environment, and has negative impact on cave resources and fauna (*National Park Service, 2015*). Caves are part of the environment thereby protected by the Greek Constitution with Article 24 and directly by Law 1650/86 (as amended by Law 3937/11). Furthermore, apart from their geological significance, they may exhibit excellent paleontological, biological, archaeological, historical, folkloric and aesthetic interest. This undeniable value attaches them strongly to the areas' developmental potential and protecting this wealth is essential in maintaining the sufficient quality of life.

Over the past years, as the legal disposal sites of solid waste were significantly fewer and environmental consciousness not as heightened in our country, illegal dumping was common at conveniently located places. This method has almost been eradicated due to sanctions by European and Greek legislation. Considering that waste discharge into potholes was not easily detectable, Municipalities had not been adequately addressed with the detection and purification of these sites, although they were obliged to carry their waste to authorized disposal sites. The indisputable difficulty and the high cost of waste disposal restoration of potholes was yet another reason for the local authorities to avoid this process. Even nowadays, illegal disposal has not ceased completely, as not local communities but individuals may still discard mainly household waste and less often CD&E waste (Construction, Demolition and Excavation waste), agricultural - livestock and industrial waste.

The consequences of the waste disposal in caves vary and are related to certain issues of environmental and cultural protection, protection of human health and they have a significant economic impact. The strict legislation on solid waste did not seem adequate to address these effects as the legislative framework and administrative practice regarding the protection of geoenvironment are seriously deficient. This study attempts both to define the legal framework and to highlight the risks

related to underground karst disposal, aiming to emphasize the need for cooperation among public authorities and research institutions in order to enable the identification of these polluted sites, organized recording and their restoration.

2. METHOD

With the aim to assess legal and administrative issues related to illegal dumping in caves, the laws of solid waste management and cave protection, as well as the pertinent administrative practice in Greece were investigated. To highlight common administrative problems, the case study of Agias Anna's pothole in Viotia is reported, a case that the Greek Ombudsman has dealt in the past. Furthermore, the impact of solid waste disposal in karstic caves and potholes are analyzed with reference to Greek and foreign literature. Additionally, institutional framework assessment enriched with officials' interviews of the Ministry of Reconstruction of Production, Environment & Energy are recorded.

3. RESULTS

MSW Management Legislation

Article 11 of Law 4042/12 (*Compliance with Directive 2008/99 / EC - Article 3.1*) defines waste as «*any substance or object which the holder discards or intends to or is required to discard*». Management, cleaning and responsibility apportionment depends on the percentage of waste type. The Directive 1999/31/EC defines, as Municipal Solid Waste (MSW) waste from households, as well as other waste which, due to their nature or composition, are similar to household waste. According to Article 14 of Law 4042 / 2012 «*.. Waste management has to be carried out without endangering human health and without harming the environment ... with no water contamination risks ... without adversely affecting the countryside or places of special interest ...*». In most of the caves household waste dumping was observed, so this study addresses mainly to this type. It's obvious that in cases of industrial waste the “polluter’s pay” principle applies, so the producer has to take over his responsibilities.

JMD 49541/1424/86 "*Solid Waste in compliance with Directive 75/442/EC*” constituted the first compliance attempt of Greek legislation with the relevant European one on waste management and

disposal issues. This JMD both demonstrated the basic principles of waste management, in order to preserve public health and the environment, and underlined the necessity of management plans (*Soufleris D., 2010*). Furthermore, through the transitional provision of Article 14, a six-month period has been given to Prefectures, in order to point out all the waste disposal facilities and to receive temporary permission. The JMD 50910/2727/2003, "*Measures and Conditions for Solid Waste Management - National and Regional Management Planning*" banned uncontrolled solid waste disposal (*Article 10, par. 2d*). Both the State and the Municipalities as well as their legal entities undertaking the waste management (*Article 30 of Law 3536/2007*), are obliged to pay fines in case they use Uncontrolled Waste Disposal Sites (UWDS) (*Article 37 of Law 4042/2012 which refers to Article 30 of Law 1650/86 as amended by Article 21 of Law 4014/11*). The article states that, regardless of civil or criminal liability, all persons as well as legal entities, which cause any pollution or environmental degradation or violate institutional provisions, are liable for an administrative fine of five hundred (500) up to two million (2.000.000) euros. Imposition of criminal sanctions provided by Article 37 of Law 4042/12 which refers to Article 28 of Law 1650/86. Furthermore, according to C-387/97 EC judgment (*Case C-387/97 Commission v Greece*) the extended retention of a source of pollution or environmental degradation, without any action being taken by the appropriate administrative departments, constitutes overrun of administrative discretion (*Greek Ombudsman, 2012*).

According to the previous National Solid Waste Management Plan (JMD 50910/2727/22.12.2003), all Uncontrolled Waste Disposal Sites (UWDS) should have been restored until 31-12-2008. The restoration program included four (4) subcategories according to the hazardousness and was launched on 29.07.2004 by adopting the MD175535/07.29.04 "*Working Group Formation for promoting restoration projects about Uncontrolled Waste Disposal Sites*". However, in 2005 the Court of Justice of the European Union declared that Greece had infringed the directive 75/442/EC (Articles 4, 8 & 9) as amended by 91/156/EC, given the fact that 1.125 uncontrolled waste disposal sites remained in operation on Greek territory by February 2004 (*Court of Justice of the European Union, 2014*). In 2009 and thereafter in 2010, the Commission sent formal notices, as Greece had insufficiently complied with the judgment and finally, in 2013, initiated the process of financial penalties (*Ministry of Reconstruction of Production, Environment & Energy - MRPEE, 2013*). Greece informed the Court that, in May 2014, 70 out of a total of 293 illegal landfills remained operational and 223 had not yet been cleaned up (*Court of Justice of the European Union, 2014*). The Commission suggested a fine of 71.180 € for each day of non-

recovery, but the Court considered that this should be linked to the restoration plan progress. However, the Court ordered Greece to pay a lump sum of €10 million. The state has aimed to restore all remaining uncontrolled and open dump sites during 2015 (*MRPEE, 2014a*). Otherwise, for every six months of non-compliance Greece should be paying a further €14.52 million. According to the Special Agency for Coordination of Environmental Actions, Greece does not possess sufficient disposal sites for MSW, as the adequacy reaches 95% and unfortunately landfill is the most common applied waste management method (*MRPEE, 2013b*).

Article 44 of Law 4042/12 provides that in case of any infringement of European legislations by local authorities, penalty fines would be directly deducted by the process of distribution from the central independent resources of the Municipalities. Also, in case the fine imposed is due to a fault or co-liability of Municipality legal entities, debts offsetting between local authorities and legal entity is possible. The allocation of fines to municipalities is performed according to their population and their degree of compliance. Basically, the above provision constitutes a preventive measure for compulsory disabling and restoring of UWDS. Furthermore, non-deduction of the corresponding funds from central resources is ensured (*Κουταλάκης Χ., 2012*).

Regional Solid Waste Management Bodies (RSWMB) have recently been established by Article 13 of the Law 4071/2012, as Public Entities and consist of prefecture municipalities. RSWMB have to propose and implement Regional Waste Management Plan. Despite the fact that the Article 35 of the Law 4042/2012 states clearly that these entities are obliged to deal with all the waste produced (industrial, agricultural, etc.), a later provision in Article 13 of the Law 4071/2012 proposed that Regional Waste Management Plan will only be applied to MSW. This last provision contradicts both earlier legal predictions and EU Directives, and therefore, it should be reconsidered (*Papathanasoglou et al., 2014*). Unfortunately, there are currently only a few fully functional RSWMB, a fact that delays the implementation of regional plans. 108 RSWMB are recorded at the National Strategic Plan and in some cases their obligations undertaken by other municipal legal entities have not yet been implemented.

Restoration permission and technical studies are required for the restoration but no Environmental Study of Rehabilitation is needed. Circulars 109974/3106/10.22.2004 and 135977/5051/14.12.2005 establish the Models for Technical Restoration Studies for UWDS. The hazard calibration fluctuates from 1 to 100 degrees. According to this circular, the risk evaluation of uncontrolled dump sites is based on the pollution source, the pollutant dispersion and the recipient. More

specifically, the following factors should be evaluated: 1) Volume and type of waste, 2) Dump site distance from aquifer and soil permeability, 3) Distance from water sources, protected areas, playgrounds, crops, homes and schools, industries, roads, quarries and mines, estuaries and other water bodies (*Ministry of Citizen Protection, 2013*).

The draft law on "*Recycling enhancement and waste management improving*" which was recently submitted to public consultation, in cases of EU legislation infringement, proposed (Article 17, 2nd par.) a Ministers Council's act to compile specific action plans for the management of MSW until the Regional Waste Management Plans are carried out (*MRPEE, 2014b*).

The operational program "*Environment and Sustainable Development*" has funded environmental interventions for 2007-2013. Integrated solid waste management is included (Priority 4). This program is going to be terminated in December 2015 and all the officially reported UWDS have been included. In most of dumping situations in caves, the cleaning task has to be performed manually, impacting directly the project's difficulty and cost. Many times speleological organizations have tried voluntarily to clean up caves.

In fact, in order to characterize an area as Uncontrolled Waste Disposal Site (UWDS), competent authorities investigate whether dumping had been systematic and contained the region's municipal waste. In many occasions, limited volume of waste disposal is observed in caves and potholes. When occasional dumping has occurred, the owner of the area from which the waste originates, is responsible for their collection and storage (Article 7 1st par., JMD 50910/2727/2003). However, it's obvious that the polluter's detection is extremely difficult and sites remain polluted. In such cases, the responsible authority for cleaning needs to be determined. Many legal approaches could be stated, depending on the area's proprietary. According to Article 75 of the Municipality Code, cleanliness of common spaces and proper waste disposal should be carried out by Municipalities. The protection and management of water resources, soil protection and unpolluted areas' surveillance are Municipality's duties as well. From the above provisions, although the communal status of caves is not easy to be argued, we may conclude that Municipality is responsible to undertake the task according to its jurisdictional responsibilities for the environmental quality. At the same time, however, legal interpretation issues apply in case occasional waste dumping has been performed in caves at public (probably forest) or private land. Public land Forestry Departments or Prefectures' Environment Departments may be competent authorities as well. Finally, intervention in private property should be

carefully considered as Article 1001 of Civil Code reclaims that the owner of the ground surface is the owner of the underground as well. According to the majority of Municipalities' Waste Regulations, owners are responsible for their property's cleaning, even when others have illegally discarded waste. Otherwise municipalities intervene and undertake cleaning, charging the owners for the expenses.

Institutional Protection of Caves

The legislative study of caves protection is quite enlightening as it is observed that, while previous legislations upheld a more integrated approach, thereafter (probably due to activation of provisions of Law 1650/86), this approach was altered. Besides that the characteristics of the protected object (cave) were conceptually separated and legal protection was established accordingly.

More specifically, Article 46 of the Regulation 941/77 "*Organization of the Ministry of Culture*" indicated that the Paleanthropology – Speleology Service is responsible for "*excavation, study and protection of caves which are of interest from natural, archaeological, historical and paleontological paleoanthropological terms ...*". Subsequently, according to Article 2 of MD 34593/1108/1983, caves were considered as part of the cultural heritage. By this MD the criteria of caves' protection was established according to the guidelines of the "*International Convention in Paris on 23rd November 1972 for the Protection of the World Cultural and Natural Heritage*", which however referred only to inhabited caves.

Nowadays, according to the archeological Law 3028/02, caves and paleontological remains are included in ancient monuments only if a relation to human existence is proved (Article 2 par. B, aa). Additionally, in paragraph 4 of Article 6, protection of ancient monumental buildings is directly provided, without any administrative act adoption requirement. By Article 7, 1st par. it is clear that ancient monumental buildings dating back to 1453, belong to State's ownership and usucaption is banned.

Till now, archaeological legislation provisions are undoubtedly the most restrictive. Practically, through a broad interpretation of archaeological provisions, Paleanthropology - Speleology Service undertakes all cave protection. Specifically, in ΥΠΟΑΙΘ/ΓΔΑΠΚ/ΕΠΣ/ΤΑΠΠΠ/36447/19973/614/307/03.03.15 document of Paleanthropology – Speleology Service the jurisdiction

“ratione materiae” under Law 3028/02 is formulated, for caves’ protection. Whereas, antiquities have not been discovered, caves are considered natural monuments and are protected by the Ministry of Reconstruction of Production, Environment & Energy. This practice has a positive and as well as a negative aspect. At one hand, legal risks are obviously posed by the lack of direct legislative delegation, but on the other hand, administrative practice, demonstrates the admirable efforts of the Ministry of Culture towards natural heritage protection (*Παπαθανάσογλου Α., Παινέση Μ., 2006*).

As a result, the foregoing caves that aren’t connected to human activity are legally protected by general environmental provisions. The protection of valuable geological features started in 1937 by Law 856/37 (National Parks). However, geotopes’ value and protection necessity has been recognized by Forest Code (Legislative Decree 86/1969). In particular, according to Article 78 of the Forest Code (as replaced by Law 996/71), wooded areas which may exhibit special geomorphological interest at the same time, can be declared as national parks. Furthermore, in par. 3 of the above Article, public lands of special palaeontological, geomorphological and historical significance, which can not be classified as national parks or aesthetic forests, may be declared by Royal Decree as "Natural Monuments".

The first structured environmental Law 1650/86 in Article 18 (2nd and 3d paragraph) introduced an enabling protection and conservation provision for individual natural features or landscapes. Caves, rocks, paleontological findings, paleogene and geomorphological features could be characterized as Protected Natural Formations (Article 19 - 4th par.). Articles 18, 19 and 21 of Law 1650/86 amended by Law 3937/11 "Conservation of biodiversity and other provisions". According to Law 3937/11 protected areas are characterized according to the International Union’s for Conservation of Nature (IUCN) corresponding categories (*MRPEE, 2010*). As a result, the following types of protected areas are listed: 1) Strict nature reserves, 2) Nature reserves, 3) Natural parks National Parks - national and regional, 4) Habitat / species management areas and 5) Protected landscapes / seascapes and Protected natural formations. In order an area to be characterized as a protected landscape or as a protected natural formation and it’s conservation priorities to be defined, General Secretary’s of the Decentralized Administration decision is required. This decision is based on Regional Secretary’s opinion and on a special report documenting the value of the protected area (Law 3937/11 Article 6, 3d par.). Geoenvironment’s clarification and disconnection from biodiversity value has been attempted by these recent provisions, although the overall legislation aiming for its maintenance. More specifically, the

geological and geomorphological value “per se” is underlined regardless geoenvironment’s assistance towards natural processes and recourses maintenance.

Concluding, the legislation of caves’ protection is complicated and administrative responsibilities require clarification. Indeed, adequate geoenvironmental protection has not yet been achieved and the competent Ministry of Reconstruction of Production, Environment & Energy (MRPEE) does not sufficiently deals with landforms’ sustainability. It should be stressed out that an administrative act is required in order to achieve institutional protection since protective provisions can not be established directly. In addition, the Ministry (MRPEE) should ensure the landforms’ protection not only through general environmental provisions, but also through Water Protection and Management legislation (Law 3199/2003 on harmonization with Directive 2000/60 /EC), since karst degradation directly impact aquifers’ quality. The Law 3199/03 also incorporates the polluters’ pay principle and the objective of maintaining or reaching a good ecological status for all water through the control of pollution by use of threshold levels and standards (*Stournaras G., 2008*).

Practical issues concern the establishment of a formal and fully mapped cave record, as well as the recruitment and training of appropriately skilled personnel, highly familiar with caves and potholes approximation and study, because their mission is not only to estimate the type and the percentage of waste and to collect samples, but also to estimate the destruction level of geotopes. Finally, the cooperation and coordination of Public Services is imperative in order to preserve our geological wealth.

Case study

An intermediation request has been submitted to Greek Ombudsman, in November 2013, by the Hellenic Speleological Society on illegal open dumping in a pothole of 35 m. depth, located near village Agia Anna in Viotia Region.

Paleoanthropology – Speleology Service of Ministry of Culture, despite its legal jurisdiction in archaeological caves (Law 3028/02) has asked Municipality of Livadia to clean up the dump site and to restore it, noting that this environmental degradation constitutes aquifer hazard.

Greek Ombudsman (*responsible senior investigators A. Papathanasoglou, M. Penessi, K. Pehlivanoglou*), according to its mediatory and supervisory jurisdiction, had made pertinent requests to

all responsible Public Services (Municipality of Livadia, Public Health and Social Welfare Service, Department of Environment and Spatial Planning of Central Greece Prefecture, Environmental Control & Quality Service of Central Greece Prefecture, Department of Water of Central Greece, Department of Environment and Spatial Planning of Decentralized Thessaly and Central Greece Administration, Committee on Environmental Impairment of Decentralized Thessaly and Central Greece Administration, Paleoanthropology and Speleology Service of Ministry of Culture). Immediate action, including coordinated inspection, control of pollution load aquifer, cleaning and restoration adequate measures were requested by Ombudsman.

Competent services were immediately activated. Environment & Spatial Planning Department of Central Greece, belonging in Decentralized Administration of Thessaly-Central Greece, has asked the Municipality of Livadia: a) to collect and remove solid waste, b) precautionary measures for uncontrolled waste disposal in the pothole (e.g. fencing, prohibitive signing, etc.). Environmental Control & Quality Service (ECQS) of Central Greece Prefecture indicated in its report at 12.12.13 the existence of the cavernous dump - site without the waste type identification and groundwater assumption being possible, because Service's personnel were incapable of descending in the pothole. Furthermore, this Uncontrolled Waste Disposal Site had not been formally reported by the Municipality to the Ministry of Reconstruction of Production, Environment & Energy. Due to the obvious environmental degradation and eyesores landscape establishment, the Environmental Inspectors Service demanded waste identification, collection and waste disposal to a legal recipient, ensuring no further dumping in the cave.

Apart from the above, an inspection was conducted in the cave on 12th February 2014, with the participation of competent services' representatives and Ombudsman. Adequate skilled personnel of Paleoanthropology and Speleology Service descended along with the Ombudsman, which ascertained extensive backfilling of cave's ground mainly by old MSW (plastic, wooden and metal household objects). Furthermore, agricultural and CD&E waste were found. Finally, the implementation of hydrogeological analyzes due to possible karstic aquifer contamination was required.

Concrete measures (road truncation, pothole fencing, waste identification, collection and appropriate waste disposal) as well as the submission of a restoration study were suggested by the Directorate of Environment & Spatial Planning of Central Greece Decentralized Administration to Municipality of Livadia. Accordingly, Decision 2107/78870 /05.05.14 of Environment and Spatial Planning Department of Decentralized Administration has approved the sanitation and restoration

procedure. Municipality of Livadia in July 2014 cut off access to the pothole and placed a prohibitory sign. The technical restoration study was assigned to a private engineer. The final Decision 4348/183973/24.9.14 of the Department of Environment & Spatial Planning of Decentralized Administration approved the dump - site restoration and has also asked for measuring the aquifer's chemical parameters through samples from proximate wells. Sites' risk rating was 41, according to Circular 109974/3106/10.22.2004. The restoration cost has already been included to Municipality's budget and recently the Economic Commission of Livadia approved the technical requirements and the project's auction. The restoration proposal of Technical Services Chief of Livadia's Municipality states that manual sorting and removal with a crane is required. Also it's referred that the maximum volume of waste was estimated at 25 meters tall (*Municipality of Livadia, 2014*).

It is worth noting that the intermediation of the Ombudsman has strengthened cooperation between services leading to effective action. The practical contribution of Paleoanthropology and Speleology Service was crucial for the verification and the environmental damage description. Furthermore, the interest of the authorized personnel for geoenvironmental sustainability was remarkable. The case's progress is still monitored as the restoration has not yet been accomplished and the adoption of the final restoration study is soon to be adopted.

Waste disposal impact in caves and potholes

- Environmental Impact

✓ Geoenvironment and Biodiversity Degradation

The Geoenvironment is not adequately protected. The legal framework focuses on the biota protection disregarding life existence based in the ground, namely the earth. Degradation and destruction of underground karst by dumping is obvious. Particularly, caves and potholes can totally be destroyed by waste disposal (*IUCN, 1997*). Speleogenesis' interruption and damages of speleothems are the most significant destructions which leads to the reduction of their geological «value per se». Equally serious

are the side effects of waste disposal to the cave fauna which, usually, is endemic and institutionally protected (*Ozimen R., 2011*). In relative Slovenian research, waste disposal sites archive has been conducted. In particular the type, the severity of destructions and recovery operations occurred were registered (*NATO/CCMS, 2002*).

✓ Pollution

Problems such as epidemics, air, groundwater & surface water pollution and creation of unsightly sites arises by waste dumping (*Λέκκας E., 1999*). Hazardous substances applied in the soil can be transferred to the environment through many routes. So substances end up "*as a gas in air, as solutes in the deeper layers of the soil and even in groundwater as easily soluble substances in it*" (*Dimopoulos G., 2001*). Pollution of soil implies aquifers' contamination as well. Furthermore, a series of air pollutants (including greenhouse gases, odorous gases, PCDD/Fs, heavy metals, PM, etc.) discharged from waste disposal and treatment processes are among the most emerging air pollution sources (*Tian H. et al, 2013*).

✓ Groundwater Pollution

Waste dumping constitutes point pollution and is one of the most significant anthropogenic groundwater pollution causes (*Jiménez-Sánchez M., 2008*). In order to understand the particularity of karst aquifer pollution, a brief reference to karstification is necessary. First of all no landscape or small karst feature could be created without water (*Stevanović Z., 2015*). According to The Hazard Ranking System Guidance Manual 2 karst is defined as: «*A kind of terrain with characteristics of relief and drainage arising from a high degree of rock solubility. The majority of karst conditions occur in limestone areas, but karst may also occur in areas of dolomite, gypsum, or salt deposits. Features associated with karst terrain may include irregular topography, abrupt ridges, sinkholes, caverns, abundant springs, disappearing streams, and the lack of a well-developed surface drainage system of tributaries and streams*». In summary, the karstification process is a result of water that destructs and dissolves soluble rock masses. Furthermore, tectonic processes extend the hydrological systems, providing access to water that can migrate into deeper sections of the thick rock mass (*Getsos k., et al. 2005*). Where extensive dissolution has occurred (mature karst), groundwater flow is carried away by

conduits «*that act as tributaries to cave streams*» (*Office of Emergency and Remedial Response State, 1998*).

In Greece the main aquifers are developed within carbonate rocks (karstic aquifers) and coarse grained Neogene and Quaternary deposits (porous aquifers) (*Daskalaki P., Voudouris K , 2008*). Vulnerability of aquifer systems mainly refers to deterioration due to an external action. The karstic aquifer is exposed to pollution, firstly because it is open at surface to the pollutants disposal, at least at their alimentation zone (*Stournaras G., 2008*). Furthermore, karst vulnerability intensifies because physical groundwater depollution processes do not take place in granular aquifers (*Ihyane B., 2012*). In particular, some common depollution mechanisms do not appear at all or appear rudimentary in karstic aquifers. Limestone sinks, shafts, sink holes etc. are also moving in a direct way (and at high speed) surface runoff underground, avoiding the process of infiltration with a by pass (*Στουρνάρας Κ., 2013*). The sensitiveness of karst systems is also relevant to the residence time of water in different parts of the aquifer (*Doerfliger et al., 1999*). The hydrogeochemical reactions depend on the exact place where the pollutant will be conserved, because in anoxic environments, some pollutants might be maintained in the matrix of the rock and released slowly and constantly towards secondary or tertiary porous parts of the rock (*Jiménez-Sánchez M, 2008*).

Because of the complexity and heterogeneity of karst systems, the movement of karst aquifers is greatly unpredictable, as well as the movement of pollutants (*Στουρνάρας Κ., 2013*). In particular, the size of the pollution can only be assessed through systematic geological and hydrogeological observation (*Lekkas E., 1999*). According to Calvin A. et al “*Pollutants are not commonly detected in site monitor wells but show up in off site wells or springs long distances from the site. Karst and fracture flow aquifers drain to springs or major pumping wells which are typically off site and may be miles away*” (*Calvin A. et al., 2009*). Fracture flow and karst aquifers are difficult and expensive to adequately characterize (*Calvin A. et al., 2009*). Vulnerability mapping is one of the most applied tools in order to protect karst aquifers and can help in decision making and proper land – use promotion. Applied methodologies, such as EPIK, PI, COP, Slovene Approach and PaPRIKa take into account the specific characteristics of karst (*Marin A. – Bartolome Andreo, 2015*). The European Action, entitled “*Vulnerability and Risk Mapping for the Protection of Carbonate (Karst) Aquifers*” is an approach, not a methodology, that implies the development of a European approach for the protection of karst groundwater. This approach can apply in a wide variety of karstic environments. Specifically, COST620

was applied in 12 test sites in eight European countries through intrinsic and specific vulnerability mapping, hazard and risk mapping, and validation (*European Commission, 2003*). Aiming to investigate intrinsic vulnerability in karst aquifers it introduced four factors 1) factor O: Overlying layers 2) factor C: Concentration of flow 3) factor P: Precipitation regime 4) factor K: karst network development (*Geo.auth.gr, 2015*). Unfortunately, there is still not an international consensus about the proper method to assess carbonate's aquifer vulnerability (*Marin A. – Bartolomeo Andreo, 2015*).

✓ Landscape degradation & Impairment of cultural value

The destruction of caves implies landscape degradation with serious socio-economic impact. The European Council designated landscape as the area perceived by man as “a result of the action and interaction of natural and / or human factors”. This expanded concept of landscape aims at balancing development of anthropogenic activities through the conservation of natural and cultural heritage. Caves and pits are parts of landscape. In the literature the term "geological landscapes" is defined as follows: "*Small or large sites, located physically on earth surface or derived from human activity and clearly present information, hydrological, paleontological, geological or geomorphological or geological phenomenon or effect of forces, including their interactions, which occurred in geologic time ... The geological landscape is definable and unique in space and geological time and in its development process. It can be compared, evaluated, classified and provide information about palaeoenvironment, paleoclimate prevailing during the formation period*" (*Damianos E., 2013*). Through law 3827/10 the European Convention of Landscape was activated. Furthermore, the draft for National Strategy on Biodiversity (*MRPEE, 2010*) concluded about the landscape protection incorporation into all sectoral policies, with particular emphasis on geotopes and palaeontological biodiversity maintenance.

- Human health risk

Human health risk is obviously related to the environmental impact. The process of health risk assessment aims to characterize the adverse health effects of human exposures with environmental hazards and for this reason several risk assistance models have been proposed. This study does not aim to

analyze the serious effects on human health by dumping, so only a very brief reference to this issue is made. Waste disposal releases large amounts of hazardous substances to nearby groundwater and to the air via leachate and landfill gas. Human health is threatened mainly from water pollution due to potential carcinogens and toxic chemicals as well as by microbiological contamination (*Klinck B., Stuart M., 1999*). Small amounts of leachate can pollute large amounts of groundwater rendering it unsuitable for domestic water supply (*Lee F. et al. 1994*). Air pollution from waste disposal arises, as well, great concerns about its adverse effect on surrounding ambient air quality and public health (*Tian H., et al., 2013*).

- Economic Impact

Illegal waste disposal creates a significant economic cost that extends to a wide range of human activity. In addition to the serious economic burden because of EU fines (*Koutoulakis C., 2012*), the economic cost includes externalities of uncontrolled dumping for the environment and health from increased greenhouse gas emissions, water pollution, reduction in land prices and the direct costs of future restoration and proper water purification (*Lalas et al., 2007*). The risks to human health and the associated external costs are higher within communities living in the proximity to relevant sites (*Rushton L., 2003*).

The environmental economy is based on the assumption that all the environmental functions have an economic value, which would be appreciated if they were integrated into a real market (*Turner et al., 1994*). Destruction of underground karst formations generates, as well, loss of community revenue from possible exploitation of caves and potholes. Economic value impairment can be assessed by Contingent Valuation Method – CVM, which based on the idea of a hypothetical market through which the Willingness To Pay (WTP) or Willingness To Accept (WTA) are estimated. “Travel Cost Approach” builds on the assumption that the cost to visit a leisure area (fuel, tolls, etc.), reflects in its recreational value (*Kaliampakos D., Damigos D., 2015*). Waste management occurs in case the uncontrolled waste disposal contributes to the degradation of high value ecosystems (*Lalas D. et al, 2007*). However, this method according to Batterman I. “*is best applied to the evaluation of well defined recreation sites or to the evaluation of a well-perceived, separable, environmental attribute within such a site*” (*Bateman, 1993*). What also should be taken into account is the reduction of the economic value due to the destruction of cultural property as reflected both in the folklore value damage and the devastation of

potential archaeological and paleontological findings within them. Cultural objects exhibit, from the perspective of the economy, strong similarities to environmental goods since these are mostly public and non-marketable (*Tolidis K. et al.*).

4. CONCLUSIONS

Greece's compliance with EU requirements for the proper management of waste evolved slowly. The particularity of the invisibility of the underground waste disposal hinders their identification and assessment difficult, while technical restoration difficulties are also huge and imply high economic costs.

However, the consequences are important, and they include both the groundwater contamination and the consequent human health risk, but also the destruction of geoenvironment. Therefore proper implementation of the institutional framework for waste management and environmental protection is imperative. Whether there is a UWDS or limited waste disposal within caves, it is urgent that these sites are cleaned.

In order to achieve this, the sites in every district should be recorded as underground polluted sites, in cooperation with competent bodies and the organizations that have the required approximation skills. Furthermore, technical restoration studies should focus on assessing the pollution of aquifers, taking the scientific conclusions on Karstic aquifer's vulnerability monitoring into account, otherwise chemical measurements are useless.

Finally, it is vital to establish a potent institutional framework for geotopes' protection and public services should clarify their responsibilities and to cooperate. Within this framework constructive partnerships will be enabled and direct funding prospects for the protection of geoenvironment could be created. Ongoing "sine qua non" training of personnel, who will assume the assessment procedures is also taken for granted.

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