RESEARCH ARTICLE **(Open Access)**

Sewage Sludge Disposal and Reuse for agricultural purposes in central Albania

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Abstract

Strategic studies are necessary to determine the best practicable environmental option (BPEO) for the management of sludge (and effluent), i.e. an integrated and holistic approach to planning treatment and reuse or disposal that is adapted to the local conditions. Sewage treatment transfers much of the pollution load contain in sewage to sludge, so that clean effluent can be discharged safely to the environment. The pollutants include nutrients and organic matter which are of potential agronomic value but also other contaminants, particularly heavy metals which may be potentially harmful if sludge is used on land without control and concentration in soil allowed to accumulate to critical levels. A wide range of synthetic organic compounds may also be found in sludge, but most of these are relatively easily degraded and are of limited concern for sludge use or disposal. The heavy metals of concern in sludge are zinc, copper, nickel, cadmium, lead, chromium and mercury, although other potentially toxic elements may be of local concern, such as selenium, molybdenum, arsenic and fluoride. While heavy metals are regarded as a major problem for sludge use on land, it should be borne in mind that at normal agronomic rates of sludge application, the accumulation of heavy metals in soil is very slow and may take several decades or even centuries of application to reach soil concentrations of concern. However, because of the strong retention in soil, concentrations of heavy metals in sewage and sludge need to be effectively controlled to protect the long-term sustainability of soil for crop production. The chemical composition of sludge is not strictly controllable but specific measures can reduce the occurrence of specific contaminants and these are necessary in industrialised catchments where the discharge of heavy metals may give rise to concentrations in sludge that may restrict the potential use of sludge in agriculture. In most countries, industrial effluent control regulations and continual improvements in manufacturing technologies that are less polluting, have progressively reduced the occurrence of point sources of heavy metal inputs to sewage. Where run-off from paved areas is combined with wastewater, atmospheric deposition of heavy metals, such as lead from car exhaust (although the introduction of lead-free petrol can effectively reduce concentrations), may be washed into the sewerage system.

Keywords: waste; sewage; sludges; heavt metals.

1. Introduction

Environmental risks include increased potentially trace elements (PTE) input, leaching of nitrogen (N) in subsurface drainage and groundwater, contamination of surface water with soluble and particulate phosphorus (P), vector attraction, and reduced air quality by emission of volatile organic compounds, among others. Most countries regulate concentrations of PTE and sewage sludges and mandate maximum permissible loading rates into soil to manage contaminants. Nevertheless, concerns associated with adverse environmental effects due to land application of sewage sludges continue. This paper investigates the environmental impact of sewage sludges land application related to soil properties.

The range of potentially feasible outlets for sludge was evaluated for Pogradec, Korca and Kavaja WWTPs; this included agriculture, forestry, land reclamation, energy recovery and landfill disposal. It is concluded that none of these options can currently be considered reliable or secure outlets for sludge, for the following reasons:

Agriculture: In view of the uncertainty over whether the quality of the soils in the areas of the WWTP can comply with soil quality standards, the use of sludge on farmland cannot be assured. Nevertheless, there is high latent demand for solid sludge as there is a deficit in animal manure which is traditionally used by farmers, although liquid sludge is not readily accepted by farmers.

Forestry: Despite the large areas of forestry in Albania, the potential for using sludge is small and periodic as tree planting activity is very limited (financial restriction). Nevertheless, the local forestry offices would be keen to use sludge, provided it is dry and easy to handle as they appreciate the benefits of adding organic fertiliser at planting.

Land reclamation: There are a number of potential options for using sludge in land reclamation in Albania: abandoned mining sites (control of soil erosion and heavy metal pollution, undertaken by the local forestry offices); quarries (restoration is a legal obligation of owners); waste dump sites (to be restored when regional landfills are available); progressive restoration of the planned regional landfills; and possibly in land development (golf courses, etc. as tourism develops). Such sites could potentially use large quantities of sludge but the opportunities are few and periodic and currently there are no confirmed projects.

Energy recovery: The only potential for recovering energy from sludge in Albania is by co-combustion in cement factories. There are currently three cement factories and more may be constructed but none are within reasonable transport distance of the WWTPs. None of the factories is adapted to burn alternative fuels although a new factory (Titan) near Fushe Kruja has indicated that it may consider burning waste. If waste-to-energy is considered as a future solid waste management option, perhaps for Tirana, then this may provide an additional opportunity for burning sludge, which may be relevant for Kavaja WWTP.

Landfill disposal: There are no sanitary landfills currently available for the safe disposal of sludge (or screenings from the inlet works of the WWTPs). Twelve regional landfills are conceived but most will take several years to realise. A regional landfill is to be constructed near Maliq (funded by KFW) and is expected to be operational in 2011, serving most of the Korca Region. This would potentially provide an outlet for sludge from Pogradec and Korca WWTPs although this will be costly due to transport distance and disposal charge (total cost estimated at €40-50/t). A regional landfill for Tirana is still only conceptual so there is no ultimate disposal option available for Kavaja sludge. The types of sludge treatment provided by the WWTPs are appropriate in that they produce sludge that is well stabilised due to the long retention periods during processing. This will result in sludges that have low odour potential and significantly reduced pathogen contents.

2. Material and Methods

Data on soil quality in Albania were collated. Much of the data are related to specific investigations of pollution hotspots resulting from previous heavy industrial activities but there are local and national studies that have focused on natural background concentrations of heavy metals. These data are strategically important with regard to using sludge on land sludge as the EC Directive sets maximum permissible concentrations of heavy metals in soil above which sludge use on land is not permitted.

The national study produced maps of the likely distributions of nickel, chromium and lead; the concentrations of Ni are shown in the figure (note: the maximum limit for Ni in soil is 75 mg/kg). The overall conclusion is that soil concentrations of nickel, and to a lesser extent, chromium and lead, may exceed their maximum limit values over much of Albania. If so, this seriously compromises the potential for using sludge on agricultural land and, based on the available data, only 10-20% of land nationally may be acceptable for sludge application. A more detailed survey, particularly of the agricultural land in the vicinity of the WWTPs, needs to be carried out to verify whether the soils are suitable for receiving sludge.

The transposition of Albanian environmental law to harmonise with *Acquis* Communautaire is not yet complete although significant progress has been achieved with the drafting of a number of new laws relevant to the water and waste sector. While these draft laws will provide the legal framework for introducing regulations on sludge, a specific sludge regulation that harmonises with EC Directive 86/278/EEC3 is not yet developed. Sludge management strategies need to be developed for each WWTP to identify sustainable and cost-effective outlets, and, in general, agriculture is likely to be the main beneficiary in Albania, if properly developed. This requires WWTPs to be designed to produce sludge of an appropriate quality that most readily secures beneficial use on land. Consequently, sludge management strategies should be an integral component of the initial WWTP design selection process to ensure an appropriate balance is achieved between affordable wastewater and sludge treatment, and securing outlets for the sludge. Sludge is a novel product in Albania as so far the only experience of using sludge on land is in Kavaja. While the purpose of this study is to develop practicable and sustainable sludge management strategies for Pogradec, Korca and Kavaja, it is inevitable that the study has to address issues and concepts that have not yet been considered in Albania but need to be, urgently, in view of rapid increase in the quantities of sludge expected in the near future.

Figure 1. Map of Albania showing Existing and Planned WWTPs

Strategic studies are necessary to determine the best practicable environmental option (BPEO) for the management of sludge (and effluent), i.e. an integrated and holistic approach to planning treatment and reuse or disposal that is adapted to the local conditions. The BPEO takes into account all of the issues relating to the practicability, environmental, social and economic implications of the feasible options of treatment and disposal under the local circumstances. This provides an objective approach to determining the best balance of costs, benefits and impacts, and to provide the most sustainable solution. Identifying the BPEO should be the first step in the WWTP design process as this determines the appropriate specifications for sludge (and effluent) quality which can then be designed for by engineers. This ‘reverse engineering’ approach saves time and money and avoids the potential need for supplementary treatment or having to use non-optimal outlets if sludge use and disposal options are identified after design or construction of the WWTP. This logical approach is not always followed in practice.

In line with the international concept of the waste management hierarchy, the priority for sludge (and effluent) management is reuse, wherever feasible, to maximise the resource value of these products. This approach is generally adopted into national waste management policies by introducing measures which prevent or discourage disposal by prohibition (e.g. banning of sludge dumping at sea), setting stringent technical standards, or by economic instruments (e.g. tax on waste disposal, emissions trading, etc.).

The potential outlets commonly considered for sludge use or disposal are: land based – agriculture (green areas, forestry, land reclamation); product based – compost production (construction materials); energy recovery – co-combustion (power generation, cement production) and disposal – landfill disposal of sludge or ash. Internationally, the preferred and common management option for sludge is beneficial use on land, particularly for agricultural production. This is widely regarded as the most sustainable option provided sludge quality and its use are controlled, and farmers are willing to use the sludge. Use in this way ensures that nutrients and organic matter are recycled to the soil to enhance crop production, reducing the use of chemical fertilisers while improving soil physical properties with regard to its cultivatability, nutrient retention and moisture holding capacity (important where irrigation is necessary). Co-disposal of sludge with domestic solid waste in landfill has been the most popular option in many countries due to its low cost, simplicity and relative ease of disposal of difficult or contaminated sludges. The physical stability of the sludge is usually the only quality requirement and a minimum of 35% ds is often specified to minimise site management and environmental problems. However, in many countries, landfill disposal of organic wastes such as sludge, is widely recognised as unsustainable due to the loss of the resource value of sludge (nutrient, organic matter, energy), limited landfill void that should be preserved for non-recyclable wastes and concern over environmental emissions, particularly methane (a potent greenhouse gas). Incineration of sludge is a treatment process for mass minimisation, preferentially with energy recovery, and may be adopted where opportunities for sludge use or disposal are limited or not available. This process is only practicable on a large-scale and incurs high capital cost, requires considerable technical ability, may need supplementary fuel if autothermic combustion cannot be achieved, and often faces planning difficulties due to adverse public perceptions relating to gas emissions and visual intrusion of the plant. The residual ash, which comprises about 30-40% of dry solids, is usually disposed of in landfill and may be regarded as a hazardous waste requiring special and expensive disposal. However, some ash components can be used for construction materials (additive to building blocks, road base, etc.).

3. Results and Discussion

3.1. Chemical Quality of Sludge

The chemical quality of sludge is complex and is dependent on the nature of the sewerage catchment, with the principal contributions attributable to: (i) domestic sewage which, in addition to human wastes, will contain chemicals derived from domestic products and plumbing systems; (ii) industrial wastewater which may contain a wide range of inorganic and organic contaminants; and (iii) run-off from paved areas which will wash in atmospheric deposition into combined drainage system. Sewage treatment transfers much of the pollution load contain in sewage to sludge, so that clean effluent can be discharged safely to the environment. The pollutants include nutrients and organic matter which are of potential agronomic value but also other contaminants, particularly heavy metals which may be potentially harmful if sludge is used on land without control and concentration in soil allowed to accumulate to critical levels. A wide range of synthetic organic compounds may also be found in sludge, but most of these are relatively easily degraded and are of limited concern for sludge use or disposal.

3.2. Heavy Metals

The heavy metals of concern in sludge are zinc, copper, nickel, cadmium, lead, chromium and mercury, although other potentially toxic elements may be of local concern, such as selenium, molybdenum, arsenic and fluoride. While heavy metals are regarded as a major problem for sludge use on land, it should be borne in mind that at normal agronomic rates of sludge application, the accumulation of heavy metals in soil is very slow and may take several decades or even centuries of application to reach soil concentrations of concern. However, because of the strong retention in soil, concentrations of heavy metals in sewage and sludge need to be effectively controlled to protect the long-term sustainability of soil for crop production. The chemical composition of sludge is not strictly controllable but specific measures can reduce the occurrence of specific contaminants and these are necessary in industrialised atchments where the discharge of heavy metals may give rise to concentrations in sludge that may restrict the potential use of sludge in agriculture. In most countries, industrial effluent control regulations and continual improvements in manufacturing technologies that are less polluting, have progressively reduced the occurrence of point sources of heavy metal inputs to sewage. As a consequence, diffuse sources of contaminants generally characterise the heavy metal profile and concentrations in sludge.

Domestic sources include dietary composition, corrosion of water pipes (major source of zinc and copper), and pharmaceutical and cosmetic products (predominantly zinc). Dental amalgam from dental practices may be a significant source of mercury but many countries have introduced measures to avoid this. Where run-off from paved areas is combined with wastewater, atmospheric deposition of heavy metals, such as lead from car exhaust (although the introduction of lead-free petrol can effectively reduce concentrations), may be washed into the sewerage system. Such sources of heavy metals are generally not easily controllable and therefore sludge will always contain baseline concentrations below which further reductions are not easily achieved. Heavy metals in wastewater are transferred to the sludge by physical processes (dependent on the settlement of precipitated, insoluble metal or the association of metals with settleable particulate matter) and by uptake or binding of metals by the microbial biomass. About 70 – 75 % of Zn, Cu, Cd, Cr and Hg in wastewater is removed and transferred to the sludge and concentrations of these elements in the final effluent would be expected to decrease by the same amount compared with the influent to the works. Lead may achieve a removal of 80 %, whereas the smallest overall reductions are obtained for Ni and approximately 40 % of this metal may be transferred to the sludge. Consequently, sludge usually contains approximately 1000 times (mg/kg ds basis) the concentration of most metals present in the wastewater (mg/l). Heavy metal concentrations in the final sludge product are influenced significantly by the type of stabilisation process operated at the WWTP. For example, sludge stabilisation processes such as extended aeration and anaerobic digestion destroy up to 40% of the volatile solids by microbial decomposition and, since heavy metals are conserved in the sludge, concentrations increase in direct proportion to the volatile solids reduction. On the other hand, when lime is added, a reduction of metal concentrations occurs through dilution, although lime addition should not be used as means to achieve compliance if sludge concentrations would otherwise be above the maximum value permitted for sludge use in agricultural.

Geostatistical analysis was performed by the Centre for Transfer of Agricultural Technologies Fushe-Kruja to produce spatial distributions of heavy metal concentrations in soil and the thematic maps for Ni, Cr and Pb are shown in Figure 2. In view of the limited data set, the accuracy of these maps cannot be verified but they at least given an overall indication of the likely distribution of elevated soil concentrations. From the data set, locations were identified that were within the vicinity of the WWTPs. There were no sampling sites in Kavaja but several in Pogradec and Korca. All of these soil samples contained nickel and chromium concentrations in excess of those that would permit sludge use on land. The pH of soil is also an important criterion in assessing whether sludge may be applied to agricultural land as the maximum soil concentrations that are permitted should take into account the increased mobility of certain heavy metals in acidic soils. Sludge is not permitted on soils with a pH less than 5 but for soils that have a pH permanently above 7, the maximum permitted concentrations of Zn, Cu and Ni may be increased by 50%.

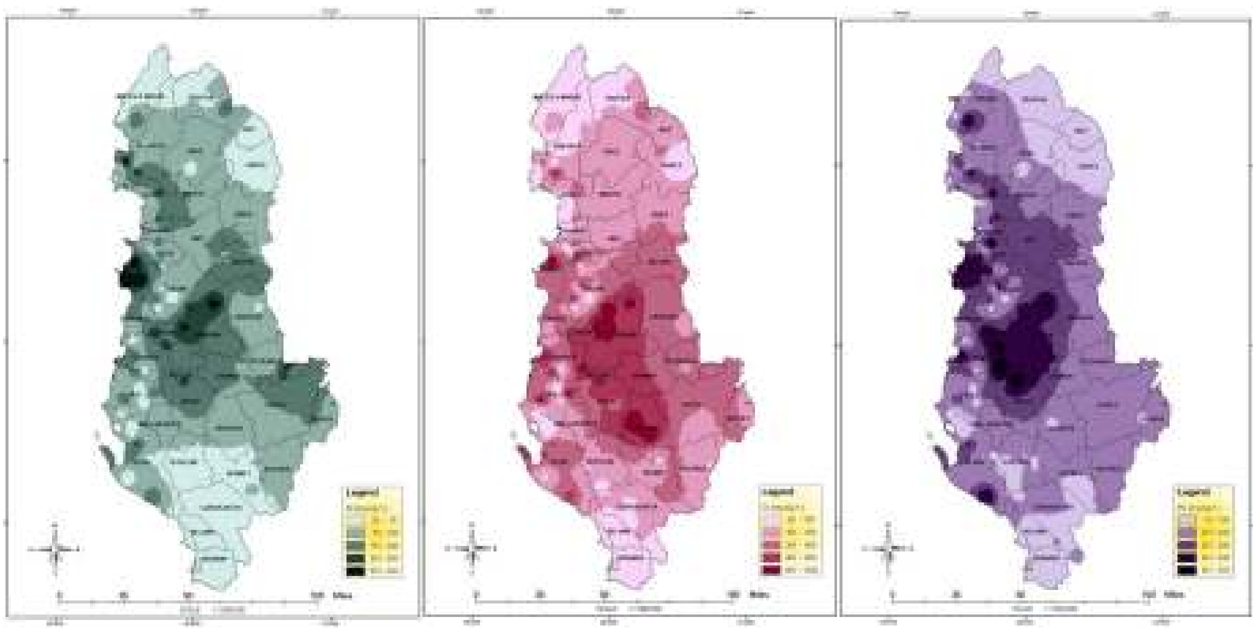

Figure 2. Geographic Distributions of Nickel, Chromium and Lead Concentrations in Soils in Albania

The pH values of the soils around Tirana were found in the range 4.38 to 7.49, whereas the national survey measured soil pH values in the range 4.7 – 8.5 with a median value of 7.7. Consequently, soils generally can be regarded as calcareous. Taken at face value, the maps of heavy metal distribution suggest that the soils over most of Albania exceed the EC limit values for nickel, large areas exceed the limit for chromium and a small proportion of soils exceed the limit for lead.

The inevitable conclusion is that the use of sludge on agricultural land in Albania could be very limited. With respect to Pogradec, Korca and Kavaja, the maps indicate that the soils around all three WWTPs may exceed the limits for Ni and Cr. There are examples of similar situations in other countries in Europe where sludge may not be applied due to natural elevated background concentrations of certain heavy metals but these areas are generally geographically small and do not usually adversely affect establishing sludge use in agriculture. The problem with the EC Directive in relation to naturally high background soil concentrations is that the limit values are based on total soil concentrations and do not take into account of the availability of the heavy metals for crop uptake. Generally, naturally occurring high concentrations of geological origin are characterised by their low availability to plants, although there are exceptions. Furthermore, the EC Directive does not recognise the fact that if the natural background concentrations of heavy metals in soil exceed those in sludge, it is not possible for the application of sludge to cause an increase in the soil concentrations. In view of these findings, it is strongly recommended that the work started by the Centre for Transfer of Agricultural Technologies Fushe-Kruja is extended to provide a more detailed and systematic survey of the chemical quality of soils in Albania. In particular, the agricultural land around the WWTPs should be analysed to determine whether sludge application is feasible.

4. Conclusions

For the comparatively low investment costs, the sludge management approach adopted is appropriate for the present capacity of the WWTP. Nevertheless, it is unlikely that such a disposal concept fits with the expansion of the WWTP as the technical and logistical requirements will increase significantly to cope with four times the quantity of sludge. The most significant constraints are that farmers have yet to fully accept liquid sludge and would much prefer a solid product similar to animal manure with which they are familiar. The period of sludge application is limited to the autumn and spring periods, requiring high intensity of sludge spreading activities by the WWTP staff over a short period of time. The farmers' plots are small which limits the size of tanker to that currently used (generally, one tanker load of 6 m3 is sufficient for one plot). As sludge production increases, more land further from the WWTP will be required and road transport of sludge by tractor-tanker will become increasingly inefficient due to extended travel times while transporting a small quantity of sludge. To increase efficiency and the area of land that could be treated per day, investment would be required in an additional tractor and tanker unit and possibly a road tanker for more efficient transfer of sludge to the field. The existing SRBs are re-established and utilised to their maximum capacity to minimise reliance on sludge spreading to agricultural land. Marketing' of liquid sludge to farmers should continue with the active support available from the local agriculture office, particularly to encourage use of sludge on field crops to ensure sufficient capacity for the quantity of sludge that cannot currently be accepted by the SRBs. The area of SRBs is increased progressively as the production of sludge increases in the future to provide 100% capacity of sludge production.

The physical quality of sludge is critical for acceptance by any of the potential options for use or disposal. Liquid sludge, as produced by Kavaja and Pogradec WWTPs, poses very specific operational constraints and limits the options available for disposal to application to agricultural land by tanker (or possibly by certain types of irrigation systems not currently used in Albania). This requires that the UKs have the necessary equipment to spread the sludge on the farmers' land (currently available only at Kavaja WWTP). It is very difficult to 'market' liquid sludge in Albania as farmers have no experience of this type of manure compared to farmers in Western Europe where liquid animal slurry is common, produced by intensive animal production. Farmers will much prefer dry sludge that can be handled and spread on land in the same manner as animal manure. This means that the UKs would only need to transport the sludge to the land on which it will be spread by the farmers, or if demand is high, the farmers may collect sludge with their own vehicles.

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