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Rubbish Theory: The Heritage of Toxic Waste

Reinwardt Academy
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About the Memorial Lectures

In 2008, the Reinwardt Academy, the faculty for Cultural heritage of the Amsterdam University of the Arts, decided to honour its namesake by organising a yearly lecture, to be held on or around his birthday on 3 June. Caspar Georg Carl Reinwardt (1773-1854) was a respected naturalist, professor at three universities (Harderwijk, Amsterdam, Leiden), director of four botanical gardens (Harderwijk, Amsterdam, Bogor, Leiden), and director of one natural history museum (Amsterdam). During his stay in the former Dutch East Indies (1816-1822), he assembled large collections that eventually found their way to several major Dutch museums of natural history and anthropology. Reinwardt maintained a large international network, including such famous naturalists as Alexander von Humboldt. The Reinwardt Academy is proud to bear his name.

As a person, Caspar Reinwardt stands for values that the Academy considers of key importance: international orientation, collaboration in networks, sensitivity to the needs of society and a helpful attitude towards students. Reinwardt was no prolific writer; he was first and foremost a teacher. Through his lively correspondence, his extensive library and his participation in a wide variety of scientific committees, he was well aware of contemporary developments in the field of science, and he considered it to be his primary responsibility to share this knowledge with his students. It is in this spirit, with reference to the values mentioned above, that the Academy invites a distinguished speaker for its Reinwardt Memorial Lecture every year.

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Foreword

What we call heritage is the result of what we wish to retain or reperform – whether it be tangible or intangible, and whether it be ideas, memories, things or practices. The act of retaining, in its turn, usually leads to handing down heritage to the next generations. In this way, a cross-generational continuity comes into being, which is generally considered in a positive light. The living nature of the transmission, however, will ensure continual change and development of those things handed down. In this way, a certain measure of forgetting is built into the process. This is an example of Heracleitus' *panta rhei* – everything is in flux.

There are things, however, that we emphatically do not wish to retain. In addition to that which is essentially evil – like nasty experiences, from bad memories to the nightmare of genocide – there are the two categories of the basically ephemeral, such as biological products apt to decay, and the intentionally transient, like wrappings, waste, garbage and trash. Unless sublimated into moral admonitions, like the monuments commemorating the Holocaust and other killing fields, all other items figure in the realm of forgetting, the non-heritage. On rare occasions some physical objects are rediscovered as rarities, thereby unexpectedly regaining value. This mechanism was first studied by Michael Thompson (1979) in his famous book *Rubbish Theory: the Creation and Destruction of Value*. In the heritage field, it sheds light on the processes of musealisation. There is one category of reality in which the fact that content will change during transgenerational transmission, combined with our intention to turn our backs on it, leads to a very uncomfortable question indeed. That is the way humanity is dealing with waste as a negative consequence of its 20th-century industrial mode of production. Chemotoxic products and radioactive waste, which remain lethal for millions of years, represent a form of non-heritage with a painful moral obligation. This spring, Pope Francis devoted a special encyclical to the matter: *Laudato si'*, on care for our common home.

The Swiss geologist Marcos Buser has been a researcher and an activist in the field of waste management for forty years. He poses uncomfortable questions to governments, industrialists and society as a whole. How do we warn future generations against our high-risk waste? This is not only an issue for policymakers or industry technicians. Many more disciplines are needed to face the immense ethical challenge underlying this issue. Heritage professionals, with their expertise in articulating and communicating significance, should be prominent torchbearers.

The inverse relationship between heritage and dangerous waste has been remarked upon before. In our country, for example, it was addressed by prof. Gerard Rooijakkers, in the first Ketelaar Lecture (2003).* Referring to the future of Borssele, one of the two Dutch nuclear power plants, he used the term 'hazardscape', nicely echoing a similar word recently introduced for holocaust loci: 'terrorscapes'. Heritage academics abroad have turned to the communication aspects of dealing with our undesired legacies, like the British-Swedish archaeologist Cornelius Holtorf.[**] However, with regard to the subject of their concern, both Rooijakkers and Holtorf can, in a sense, be considered bystanders, whereas Buser, as a long-standing and conspicuously critical member of the advisory community on nuclear decision-making, is definitely a first-person actor.

This is not a sweet story. The prospects are bleak, the countervailing powers immense. However, when an audience member questioned Buser's strikingly gentle and optimistic outlook in the face of the gloomy subject matter during the discussion following his 2015 Reinwardt Memorial Lecture, he answered: 'As a geologist, I naturally reckon with truly long periods of time, so several millions of years perhaps don't scare me as much. In addition, I am a musician.' Through the latter remark, he made us aware of the background music that evening, a recording of the song *L'Oubli* (Oblivion) sung in French by Julia Schiwowa, with lyrics and guitar accompaniment provided by Marcos Buser himself.

Amsterdam, July 2015
Riemer Knoop, Professor of Cultural Heritage, Reinwardt Academy

[*] Rooijakkers, G.W.J., *Rituele depots. De droesem van het leven*, 's-Gravenhage: Nationaal Archief 2004; http://www.kvan.nl/files/Ketelaarlezing/Ketelaartekst1_2003.pdf.

[**] Holtorf. A., and A. Högberg, "Communicating with future generations: what are the benefits of preserving for future generations? Nuclear power and beyond", in *The European Journal of Post-Classical Archaeologies* 4, 2014, 315-330.

I
Introduction

To appreciate the nature of my theme, toxic waste as part of cultural heritage, let me take you to the shores of Lake Neuchâtel, a shallow Swiss lake on the steep southern slopes of the Jura mountain range. Sometime in the late Magdalenian, around the end of the last Ice Age, which is still referred to as the Würm glacial stage, the hunters of wild horses and reindeer left the bones of their prey around various fireplaces of their camp. This camp, including its bones that have been preserved up to the present day (Figure 1), was discovered around 15,000 years later. It is a good example of mankind's handling of waste, or indeed the lack of it: an early form of littering where non-recyclable objects were carelessly discarded. It will not surprise you that such behaviour patterns still persist today.

It seems that waste is a loyal and challenging companion of mankind across all ages and cultures. Archaeologists have found numerous remains that document the handling of waste, from the Neolithic and excavations in Troy or Rome through excavations in sites from the Middle Ages up until modern times, thereby perpetuating this careless waste handling image. Literature also provides evidence of this state of affairs, as exemplified by the impressive descriptions of Seneca (1st century AD) in his *Naturales quaestiones*, in which the great philosopher reflects on the widespread contamination of groundwater through waste.[1] In art, the subject is immortalised in the impressive mosaic of Sosus of Pergamon (2nd century BC) and illustrated by numerous copies of it scattered across the ancient Mediterranean world (Figure 2). Sosus was primarily concerned with depicting the floor of a room covered with the remains of a feast. This behaviour – carelessly leaving litter behind – has been replicated by countless generations right up to modern times. However, a shift in the perception of waste is now under way, though waste is still regarded as something unpleasant, dirty and undesirable. In the context of my presentation, the social aspect of waste will be highlighted from another angle. I will not be focusing my attention on the toxicity of waste, but rather on the social importance of our technical heritage for future generations. The thesis put forward here is that waste, which is an anthropogenic product, should also be regarded as a form of cultural heritage, even if this legacy primarily carries negative traits and in fact represents a burdensome heritage. This is an onerous legacy, which is clearly in contrast to the great cultural achievements of mankind we are proud to extol, yet like any other work of art reflects great human and cultural activities.

Figure 1: Littering at Stone Age site of Laténium Hauterive, Switzerland.

Figure 2: Banquet leftovers, Roman mosaic, Vatican (early 2nd century AD).

II
Shift of perception

Recent decades have seen an increasing awareness of the problems caused by waste in industrialised nations. Of the many factors involved, I think four reasons deserve to be highlighted here: technology, scale, politics and cultural optimism.

Technological developments and the associated change in waste quality in the past two hundred years are the first and foremost reason. Throughout human history up until the beginning of industrialisation, most waste materials were 'natural' products that were often returned to 'nature' when decomposed, in contrast to more recent industrial waste, the properties of which differ greatly from its predecessors. Let us bear in mind that with the emergence of chemistry at the beginning of the 19^{th} century, and the spread of organic chemistry in particular, materials were synthesised that never occurred in nature. These materials have special inherent characteristics, such as fire resistance, biological effectiveness or solubility properties used in a variety of products, such as industrial products, everyday household items and in agriculture, not to mention their use as military weapons. Examples include DDT or lindane used as pesticides,[2] 'Agent Orange' / dioxin or mustard gas used as toxic sprays in wars, polychlorinated biphenyls in hydraulic fluids or paints, or chlorinated hydrocarbons that have been used as solvents for decades. The list is endless. Furthermore, we should not forget the key role played by nuclear technology. The infinite range of dangerous substances or hazardous materials is as extensive as the list of sites where the residues of these toxic substances are dumped or stored (Figure 3).

Figure 3: Chemical waste at Bonfol dumpsite, Jura, Switzerland.

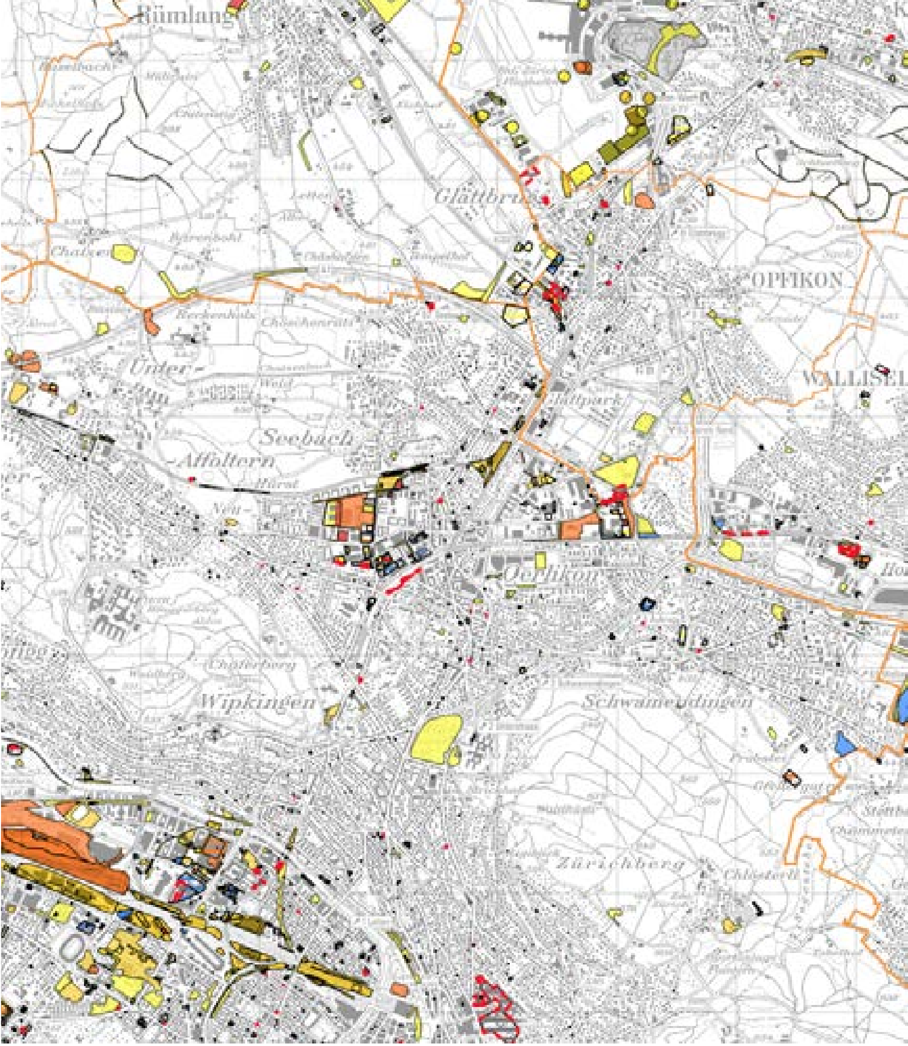


Figure 4: Distribution of pollution, sector Zurich north.
Legend: yellow: low contamination, no damage or nuisance expected / dark yellow: contaminated, no further investigation or clean-up needed / blue: contaminated, needs investigation / orange: contaminated, needs monitoring / red: contaminated, needs clean-up / red dotted line with gray hachure: in preparation. Grid: 1 km square.

We thus reach the second reason: the universality of the problem. Waste, and in particular toxic waste, is not a marginal problem that may possibly emerge every so often. It is a universal, fully visible or detectable phenomenon, which occurs both in industrialised and emerging or developing countries, irrespective of our perception. The massive flows of material and energy used for the manufacture of infra-structures, buildings and products can also be found in waste streams and disposal sites. Both our urban and rural environments are indeed paved with contaminated disposal sites, though most citizens may not perceive this fact or are not willing to perceive it (Figure 4).[3]

This brings us to the third reason, the logic of production in industrial societies and the management of the resulting environmental and social damage. As will be clear to anyone familiar with the history of industry and technology, little to nothing has basically changed in terms of the logic of production since the beginning of industrialisation. This observation is inherent to the industrial method of production and cannot be attributed to political systems, irrespective of their capitalist, communist or other principles. The history of technology is not primarily a history of science and technology, but a history of capital and its ability to use science and technology to serve its interests in an integrated way.[4] The history of environmental pollution should, therefore, also be regarded as a consequence of this integration. The massive damage to the environment in recent decades has stimulated innovative thinking, starting with Rachel Carson's seminal book *Silent Spring* (1962) (Figure 5), and led to legislative amendments, as well as concrete sets of preventive measures, in developing nations. Pollution prevention and the 'polluter pays' principle are now fully endorsed by national parliaments and international organisations, which have committed themselves to the principles of sustainability. However, the fact remains that the price dictates the market. Waste, as an undesirable residue of production, should cost as little as possible or preferably nothing at all. Waste is waste in the truest sense of the word. This applies to the gaseous waste emitted into the atmosphere via combustion of hydrocarbons or as a result of intensive animal husbandry,[5] to the liquid waste discharged into rivers and groundwater via the sewers or due to intensive fertilisation, as well as to the solid residues generated by all kinds of production and consumption processes. In this regard, we hardly differ from our ancestors, as our current social system is also only marginally willing to deal with such residues. We shall later return to this issue, which will have an enormous economic impact on future generations and, ultimately, reveal the irrationality of an economy based on short-term interests.

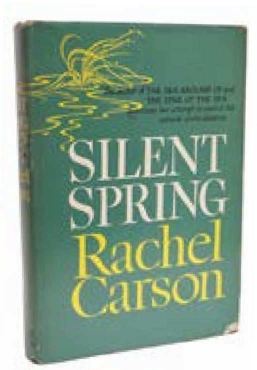


Figure 5: Cover of Rachel Carson's *Silent Spring*.

The fourth reason for the lack of awareness relates to the idea of progress, which has prevailed since the Age of Enlightenment and spread, in particular, to the fields of technology and science.[6] Ever since the start of European industrialisation, the scientific theory of positivism of Auguste Comte (1798-1857) has prevailed and developed in all areas and at all levels – scientific, technological and social. Everything, one feels, has been solely geared towards achieving progress. Doubts concerning this belief, mainly raised by Marxist thinkers, have been rare and have had little impact.[7] Faith in a better future predominated and still prevails, including in the waste sector. The former CEO of British Nuclear Fuels Limited declared, for example, in the recent documentary film *Journey to the Safest Place on Earth* by Swiss filmmaker Edgar Hagen,[8] that in the early days of nuclear energy use, no importance was attributed to the waste problem. At that time, he said, focus was placed on the production of electricity, with the waste problem put on the back burner, as it was considered to be surmountable. This abiding faith in technological progress and in the solution of all technological problems also resonates in the statement of the former director of the Swiss Federal Office of Energy who declared on the occasion of a symposium in 1979: ‘Today, the waste problem is certainly not yet solved in Switzerland. What we believe – you will say: “Blessed are those who believe!” – is that the waste problem can be solved, if necessary also in Switzerland.’[9]

III From discarding to shooting into space

The confidence in the solvability of the waste problem was voiced time and time again by experts, business leaders and policymakers over the course of several decades. It forms a strange contrast with the waste management practices that were actually implemented and which, unfortunately, still persist: the tipping of waste into pits and quarries or on dumps, the disposal of it in old mines or its discharge into water (Figure 6).[10] You are mistaken if you think this practice has only been implemented with household or construction waste. For decades, large quantities of the most dangerous waste of our civilization were disposed of in this manner, even waste from nuclear production, especially from nuclear power plants and nuclear arms production. Large regions, of hundreds of square miles or even more, were contaminated in this way – just think of the nuclear facilities of Hanford in the state of Washington (US) or of the Soviet Russian counterpart Mayak Chelyabinsk in the Urals, to name just two of the most contaminated military areas.[11] Radioactive waste was systematically dumped into the environment, including places such as large burial trenches or seepage trenches,[12] by, for example, the second of the three major American atomic bomb factories in Oak Ridge, Tennessee.

The concepts for handling and dealing with radioactive waste became more absurd, as problems increased. All parties concerned were ultimately well aware of the significant radiological danger emanating from this waste.

Figure 6: Toxic waste drums in the old mine of Fours à Chaux, St-Ursanne, Jura, Switzerland.

It was clear to them that tipping this waste into pits, special seepage basins or ocean disposal (Figure 7) were not permanent solutions. For about three decades until well into the 1980s, the weirdest and most absurd waste disposal concepts were developed for undesirable waste, ranging from total dilution of the radioactive substances in the ocean, and fusion of hot waste and environmental rocks in a cavity created by a nuclear bomb (DUMP project),[13] to disposal of highly radioactive waste in the Antarctic ice,[14] and shooting waste into space.[15] In spite of all the bizarre concepts proposed, a trivial waste dumping method was finally implemented, namely disposal and covering.

Figure 7: Dumping of radioactive waste in the Northern Atlantic.

‘Interim storage’ was a second strategy that increasingly gained acceptance. However, it implied that the waste disposal problems were not urgent and thus conveyed a false sense of security, also to the public at large. Over the last sixty years, more than 300,000 tons of heavy metal from high-level spent fuel have been stored in ‘interim repositories’, and an end to this practice is not in sight. This is all the more troubling since most of the concretely planned repository projects will require decades, or even longer, to be implemented.

IV
Pigsty earth

Due to the presence of radioactive waste and chemotoxic waste materials, mankind is literally faced with a problem of unprecedented magnitude. It is not the volume of waste that is crucial, but rather the hazard, or its toxicity, for so-called higher organisms, as well as the length of time such waste remains hazardous. This applies to both hazardous waste and nuclear waste, even if the handling of radioactive waste is significantly more complex. Both types of waste are highly toxic and also have two more extremely problematic properties.

First, they transform themselves over time. For example, persistent organic pollutants are converted into so-called 'metabolites' by chemical or bacterial decomposition, or else by exposure to light. These transformation products are sometimes far more toxic than the actual source materials. The same principle applies to the decay chains of nuclear waste, which follow strict physical laws of material decay. However, although materials and processes differ, the result is similar. Since the waste mixtures change their composition over time, the implementation of solutions becomes particularly challenging. A toxicity curve for high-level waste exemplifies the variability of the various hazardous materials in time – in this case, the so-called 'actinides', which also include the well-known plutonium isotopes (Figure 8).

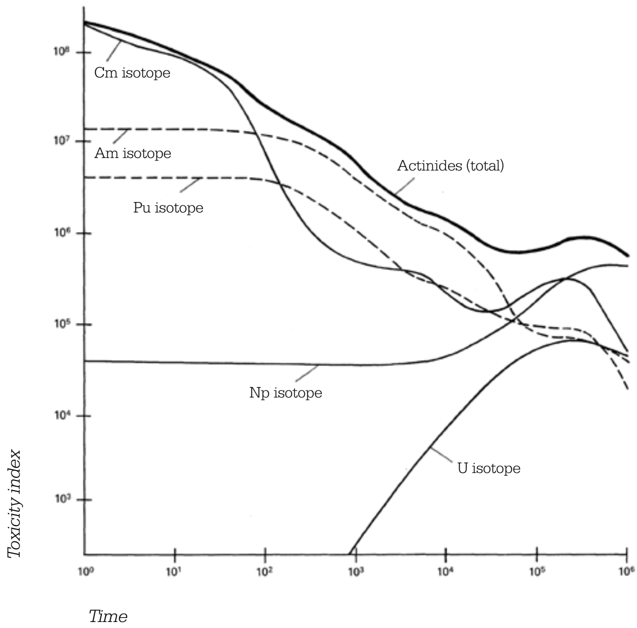


Figure 8: Toxicity of actinides in high-level waste through time (logarithmic). Different long-lived isotopes from transuranic elements decay very slowly: within one million years, the toxicity index of actinides drops only by a factor of 1,000.

The second characteristic is the long-term harmfulness. Organic hazardous waste can be harmful for thousands of years, radioactive waste for hundreds of thousands to millions of years, and stable heavy metals are toxic forever (Figure 9). By measuring these periods backwards, we become aware of the time during which such waste poses serious risks. In the case of radioactive waste, they exceed at least five times the life span of Homo sapiens. Human behaviour can be compared to that of the sorcerer's apprentice of Lucian of Samosata, the Syrian-Greek satirist (2nd century AD) – an apprentice capable of transforming our planet into a squalid pigsty within a few centuries.[16] Based on this knowledge, we can gauge the social consequences of human activity that I would like to elucidate. Let us start with some thoughts on the ethics of action and responsibility.

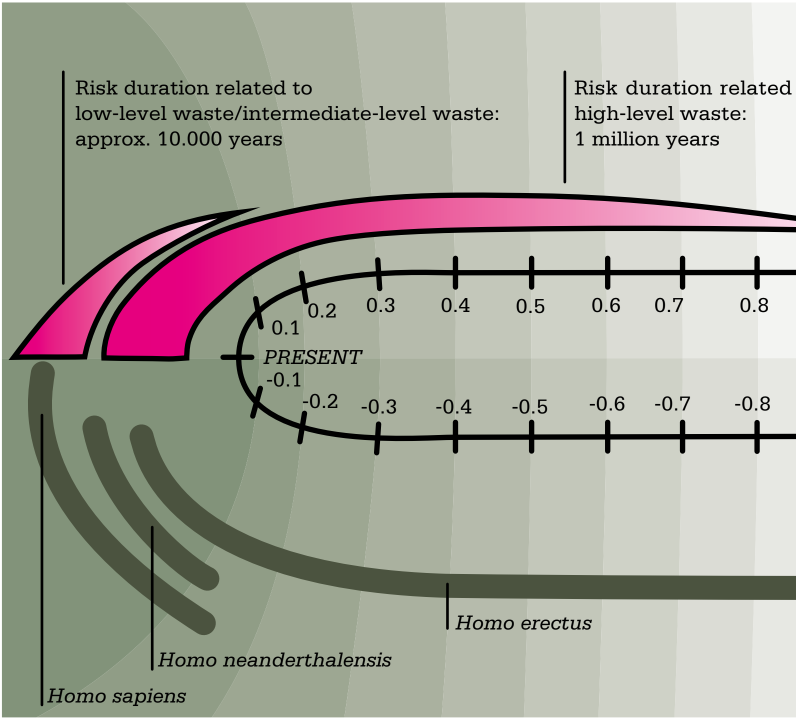
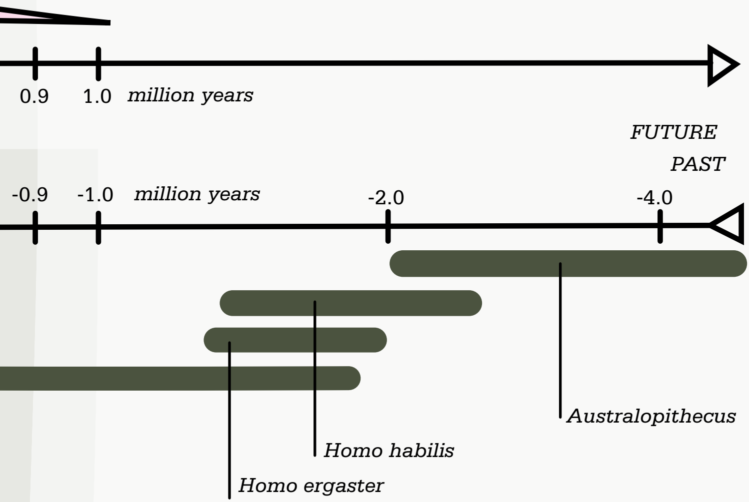


Figure 9: Time spans for radioactive waste disposal – design Marcos Buser.

to


0.9
1.0
million years
FUTURE
PAST
-0.9
-1.0
million years
-2.0
-4.0
Australopithecus
Homo habilis
Homo ergaster

V
Responsibility and perception 'above threshold'

The quest for goodness, as represented by modern ethics, or else in the older 'moral philosophy', is as old as society itself. In our culture it is influenced by Judeo-Persian (thus Zoroastrian) values and later mainly by Greek philosophical thought. The search for correct behaviour emerges in every historical period and still prevails in our modern times. The dropping of the first two atomic bombs on Japan in August 1945 shook the opinions of many contemporaries (Figure 10). Many nuclear physicists at the forefront of research and development were stunned, unable to believe that such a bomb could be built, as revealed by the secretly intercepted conversations of captured German nuclear scientists in the country estate of Farm Hall in Cambridge.[17] The dramatic impact of these weapons, and the ensuing suffering they caused, leaked despite the very restricted visual information from Japan, paradoxically leading to a 'devaluation of the

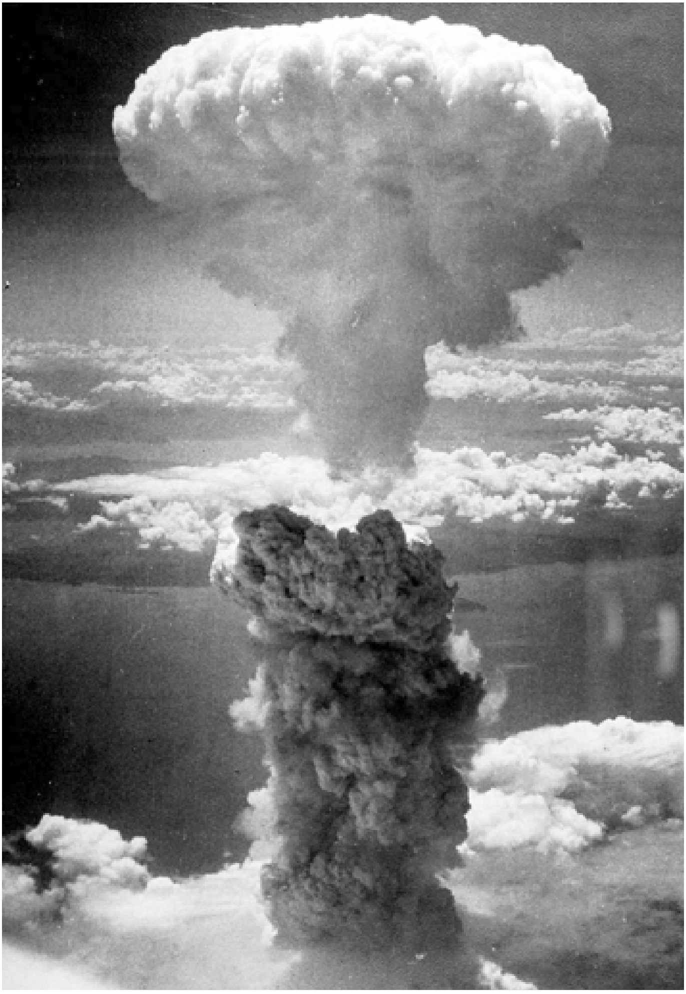


Figure 10: Fat Man, atomic bomb over Nagasaki, 9 August 1945.

sense of civic responsibility', as noted by the journalist Robert Jungk, who was the first to retrace the history of the development of the atomic bomb. In his 1963 book,[18] Jungk cites a speech given by Albert Einstein in 1947, in which the latter noted in dismay that the public was "aware of the dangers of nuclear war", but did nothing to prevent it and even tried to totally repress the warning from its conscience. These experiences deeply influenced two German philosophers who had fled Nazi Germany and who placed the issue of accountability of human action at the forefront of their considerations, namely Jonas and Anders.

Hans Jonas and Günther Stern (or Günther Anders as he later called himself) knew each other from their student days in Freiburg, where Edmund Husserl and Martin Heidegger were their teachers. As Jews, they dealt with the consequences of the Holocaust, like Hannah Arendt who was a close friend of the two philosophers and may have even been romantically involved with them. The analysis of this deadly machinery, driven by malicious and trivial power together with its destructive systems, may have hardened the opinions of the two philosophers about the devastating long-term consequences also inherent to such systems. Despite their different philosophical approaches, as exemplified in *The Outdatedness of Human Beings* by Anders (1956) and *The Imperative of Responsibility* by Jonas (1979), these thinkers recognised the key elements of technological development and their relationship to power and powerlessness. The atomic bomb and the extreme violence and omnipotence they represented had fundamentally changed the understanding of ‘the essence of modern technology’ (Heidegger). The future was no longer open; the global threat of nuclear armament became universal and timeless.[19] Jonas thus picked up the idea of the intrinsic belief in progress, already covered by the literature on Enlightenment, and revealed the interrelation of the idea of progress with the principle of growth that constantly confronts us in today’s, what many still optimistically call, ‘free market economy’. Another aspect of key importance within this context is Jonas’s perception of the effects of technological actions, from which he inferred that future ethics would have to gauge the magnitude of the long-term effects of such actions.[20] He demanded an ‘ethics of long-term responsibility’, thus addressing one of the major issues of any technology with long-term consequences. However, Jonas also noted that knowledge was the first step on this path, and he wrote: ‘As long as the risk is unknown, you do not know what needs to be protected and why...’ and, a little later, ‘We only know what is at stake when we know it is at stake.’[21]

Günther Anders upheld a more radical approach. The atomic bomb and its effects increasingly became the central theme of his work. Two publications provide a particularly succinct insight into this topic. In his first book on the subject *Die atomare Drohung. Radikale Überlegungen* (The Nuclear Threat: Radical Considerations), published in 1972, he postulated theories on the nuclear age and denounced society’s blindness to the apocalypse by revealing the discrepancy between the production capacity of human technology and the limited capacity to evaluate its consequences. He wrote: ‘We are actually inverted utopians: while utopians cannot produce what they imagine, we are unable to imagine what we produce.’ He called this discrepancy the ‘Promethean gap’, and referred to the cause of this blindness as the ‘above threshold’, namely ‘that which is too large to be capable of still triggering a reaction, for example, an inhibition mechanism.’[22] This ‘above threshold’ concept perfectly matches the situation inherent to human action, as well as the environment obviously, which includes the climate, micropollutants, plastic planet, overuse of water resources, and the extinction of species or waste. We encounter the same problem-creating mechanisms and defence strategies among mankind and the systems that Anders paraphrased as ‘blindness to the apocalypse’.[23] Like Jonas, he used the concept of fear when, in 1962 at the time of nuclear armament and the Cuban missile crisis, he remarked: ‘The troubling fact about our nuclear misery is actually attributed to the fact that it is not at all or hardly perceived as misery, and certainly not with the same consistency and severity with which the misery of exploitation of the proletarians of the 19th century had been experienced.’ Anders thus addresses something extremely fundamental, namely the fact that we can hardly fathom the impact of our future actions. The ‘above threshold’ means exactly that: the brain of Homo sapiens is clearly not designed to process such complex systems. Our emotional and empathic system fails above a certain dimensional threshold. We all know this from experience: we can vividly imagine a sum of 735 euros and 20 cents because the value can be mapped in everyday life. But how does a human brain deal with the sum of $1.4 trillion, written off in no time during the recent economic crisis of 2008? Or in other words, 1,400 billion or 1.4 million, million dollars? Such dimensions are alien to our perception. And how are we expected to perceive the consequences of toxic and nuclear risks if we cannot even correctly assess monetary values?

VI Dimensions of repression

This discussion brings us to the vast discrepancy between reality and the projected dream world we like to live in. Truth and reality remain extremely challenging topics. Construction and deconstruction of reality have been analysed and mirrored by many thinkers in the 20th century. By applying this insight, i.e. the all-too-easy acceptance of things above our threshold of comprehensibility, to the environment, and especially to our waste world, we first discover an extremely widespread naivety among competent and responsible institutions, as well as among political and economic decision makers. A comparison between the financial world and environmental problems is striking. An interesting fact is that the worst consequences in particular reveal remarkable parallels. Experts and politicians will always downplay reality, stating: '*An environmental disaster will never lead to major damages.*' Or: '*The environment is never really affected.*' Should a disaster occur, such as in the recent case of Fukushima, the consequences are mitigated, played down or glossed over. Just like in the financial sector, nobody is actually responsible for miseries and if those responsible still need to be found, the culprits will of course be identified among the lower ranks. During the last decade, for example, the managers of large Swiss banks were not officially informed of the activities of their staff, in spite of the resulting billions in losses and billions in fines. According to this model, the responsibility for the damage caused by our high-tech and financially subordinate society is already being negotiated publicly.

I would now like to give you a glimpse into the world of waste based on over forty years of activity as an expert. I have hardly ever met leaders who took responsibility for their miscalculations and errors. No one assumed the blame for the debacle of the large-size hazardous waste landfills of Bonfol or Kölliken in Switzerland, which are currently being restored at a cost of several hundreds of millions of euros (Figure 11).[24] In the nuclear field, all Swiss siting programmes for nuclear waste repositories developed since 1969 were abandoned, despite warnings from leading scientists and even safety authorities. The forecasts made in 1979 by geologist Hans-Helge Jürgens and his team, concerning the instability of the experimental repository in the now defunct Asse salt mine near Hanover, were swept aside as quickly as possible by those responsible at the time. This concern has now been confirmed, with water penetrating into the damaged mine, and the site must be restored, which is costing billions of euros of public money. However, those who warned about the situation have been punished and those responsible have been rewarded.

Such examples abound: since the subsoil of landfills is permeable, a few decades later the landfills start emitting pollutants into the environment and into groundwater, and will keep doing so for hundreds or thousands of years. We fill old salt mines with highly toxic chemical waste in the mistaken belief that water ingress can be controlled, in the long term as well. As soon as such a strategy has been implemented, interest diminishes and it is soon forgotten. The general public is not particularly interested in questioning the practices and causes behind these procedures. The logic behind the production machinery would be dramatically disrupted if conclusions had to be drawn. Yet what really occurs is that these problems are merely passed on. Not a particularly nice attitude towards future generations, who will eventually have to clean up the mess we leave behind.

Figure 11: Cleanup and restoration of the Bonfol site, Switzerland.

Figure 12: Reused Roman building blocks, Duomo, Pisa, Italy.

VII
Beacon of hope: man as recycler

At this point, it is good to know that man has always been an exceptionally good recycler of all reusable material. Let us therefore hope that he also pursues this path in the field of waste management. Ever since the earliest times, and as revealed by archaeological evidence, man has used practically everything his predecessors left behind (Figure 12). When describing the Great Mosque of Kairouan in Tunisia, North Africa (Figure 13), the writer Guy de Maupassant painted a particularly impressive picture of man's recycling and redesigning capacity: 'In the entire world, I know of only three religious buildings, besides this barbaric and intriguing building, that have left such a surprising and overwhelming impression on me: the Mont-Saint-Michel, San Marco in Venice and the Palatine Chapel in Palermo [...] Here it is completely different: a roaming population of fanatics barely capable of building walls arrives in a land covered in the ruins of their predecessors, carries everything they consider to be most beautiful here and – driven by a sublime inspiration – builds a house for their God from the rubble; a house made of fragments taken from crumbling cities that is as complete and magnificent as the purest creations of the greatest stonemasons.'[25]

It should also be noted that no area is immune to this great ability to recycle, not even intangible heritage, as evidenced in the reuse of everything from simple letters and alphabets to ideas and intellectual property. And we can at least hope that many of the 'sins' of recent decades will be remedied, as suggested by the first clean-up campaigns. It is also a fact that this does not come for free. Compilations of cost data reveal that many remediation projects cost about a hundred times the amount originally spent on disposal. Passing on our problems to the future will encumber our descendants with spiralling costs – an aspect which regrettably qualifies as 'above threshold'.

Figure 13: Main street and mosque, Kairouan (Tunisia). Photochrom print, ca. 1899.

VIII
The downside: long-term mausoleums

The management of types of waste other than building materials will be more difficult. The particulate (microscopically small) matter in the atmosphere, soil and groundwater, or the quadrillion plastic parts floating in the sea of our ‘plastic planet’, and the so-called ‘pathways of marine plastic into the ocean garbage patches’, need up to hundreds or even thousands of years until ‘nature’ has completed its cleaning process. The prospects are even gloomier for the most dangerous anthropogenic waste from nuclear energy and atomic bomb construction. To date, there is no proven technology that can eliminate these substances, while the assurances for a transmutation of radionuclides claimed by nuclear industry do not look rosy, both in terms of technology, risks, time and also costs. From our current perspective, high-level waste will invariably accompany the future of mankind, whether as contaminated sites or as specially identified or even guarded sites. Today, the prevailing consensus of opinion is to store such waste in different types of host rocks of the geological bedrock at a depth of 500 to 1,000 m (Figure 14). Of course, this concept is associated with challenges of a particular kind, which have already been recognised and studied in extensive scientific studies several decades ago.[26]

The danger of intrusion into a deep repository by future civilizations brought to light the Achilles' heel of the continental disposal practices, which relentlessly and rather quickly led to addressing and dealing with the topic of protective measures on the surface. I encourage you to view the force and impact of such events in a short documentary on the Lake Peigneur sinkhole disaster in Louisiana. In 1980, an entire lake emptied into a deep salt mine as a result of an oil drilling mistake, destroying 26 hectares of surrounding land at a cost of 45 million dollars (settled out of court by Texaco). The disaster documents the vulnerability of mines to the penetration of a single hole of perhaps 200 mm in diameter.[27] Such incidents decisively influenced the scientists and institutions responsible for the planning of repositories. At the beginning of the 1980s, American scientists started addressing the question of protecting repositories from intrusion, and published a number of papers dealing with issues such as transmitting information and warnings over thousands of years.[28] A Herculean challenge! The megalithic monuments of the Stone Age (Figure 15) and other monumental buildings of Antiquity, like pyramids or temples, were used as guidance

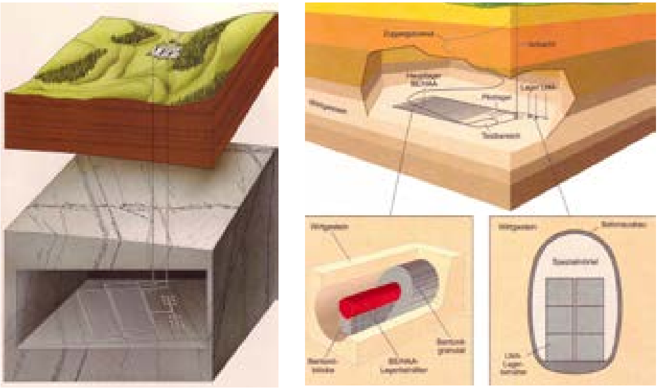


Figure 14: Disposal concepts for radioactive waste from the Swiss disposal programme. Left: Repository for high-level waste in crystalline rocks. Right: Repository for spent fuel, high-level waste and long-lived intermediate-level waste in Opalinus Clay.

Figure 15: Megalithic Stone Age monuments, Anta Grande do Zambujeiro, Evora region, Portugal.

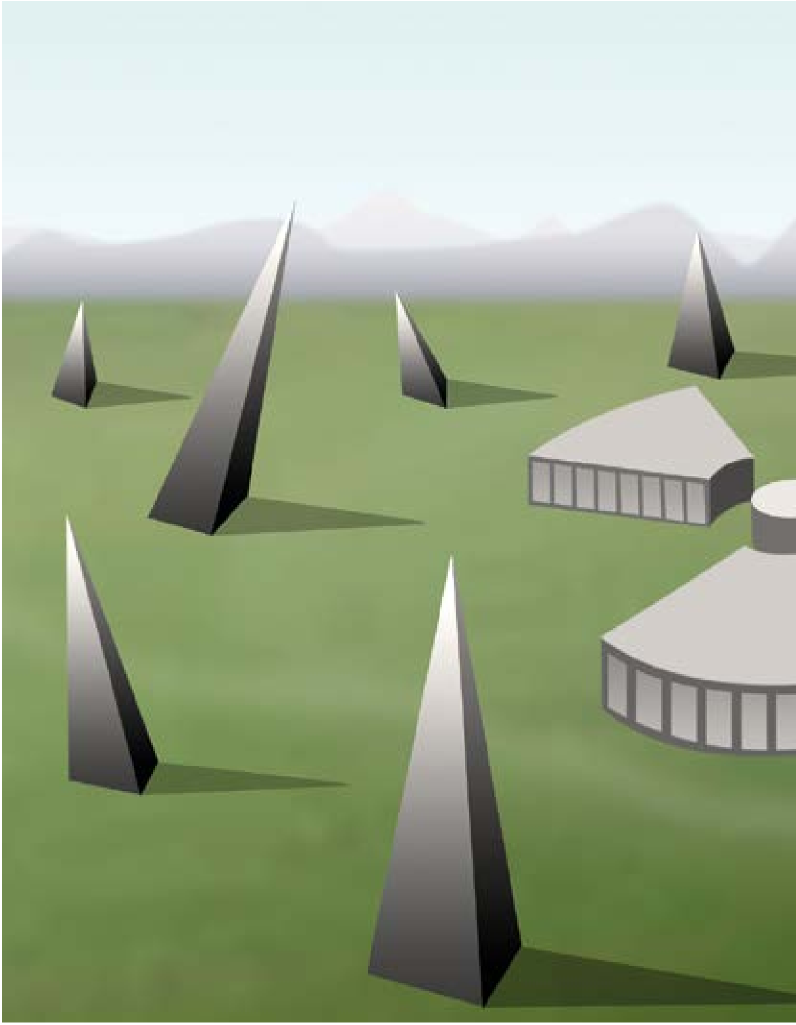
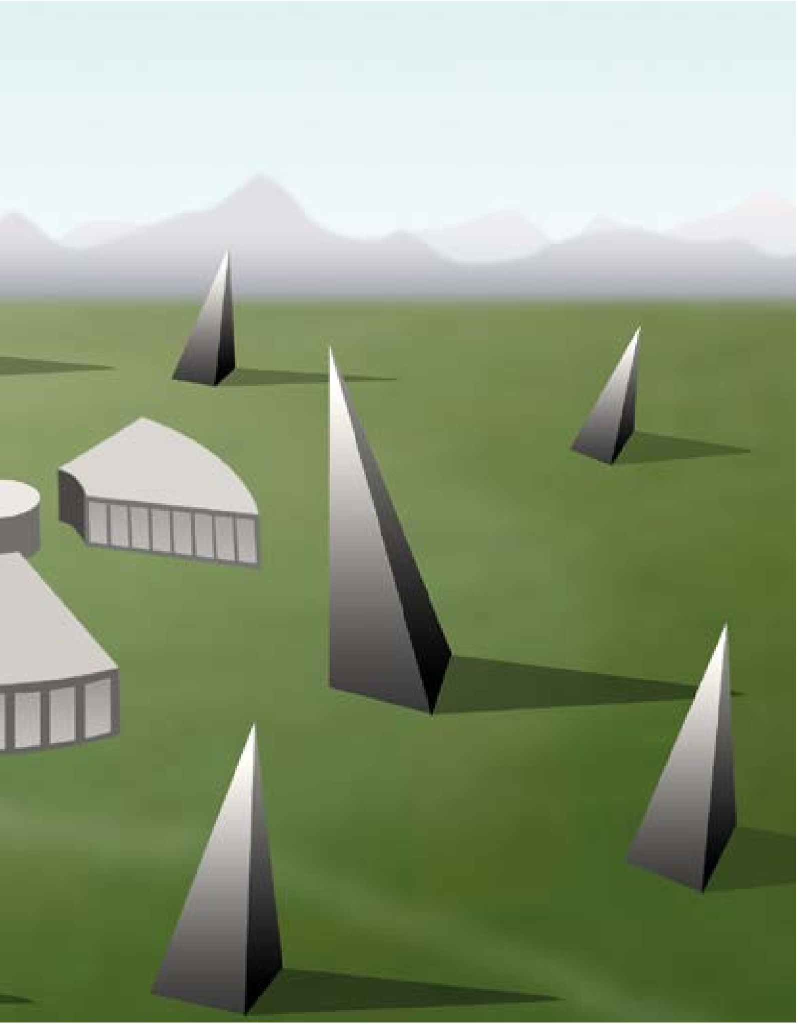


Figure 16: US surface marker concepts for radioactive waste repositories, dating from the early 1980s.



for the actual planning of surface warning messages. 'Marking studies', as they are called in the US, included reinforcement options for the surface of repositories using metre-high granite spikes (Figure 16). Pictograms and ideograms with dissuasive content or protective masks, scattered and placed in large numbers on the repository, should deter and prevent future viewers from drilling or opening the repositories (Figure 17). Visual artists were also solicited and they were fascinated by this task. One of the first who presented such a draft was Anton Lehmden, a professor at the Academy of Fine Arts in Vienna. He proposed that radioactive waste should be stored in huge steel balls, dozens of meters in diameter, the so-called 'atomic eggs', which would be surrounded by thick concrete walls (Figure 18). But can dead stone, steel or plastic survive such periods at all? We have already referred to the possibility of recycling, but that will mostly apply to valuable materials. An ideological dimension could also endanger such sites, as revealed by the examples of the Buddha statues of Bamiyan in Afghanistan, the tombs at Timbuktu in Mali and, most recently, the Assyrian ruins at Nimrod and Nineveh in northern Iraq. An evaluation of these incidents reveals that especially ideological and symbolic buildings are at risk. However, waning interest and the abandonment of monuments will soon cause such sites to be forgotten and lead to an interruption of the warning system.

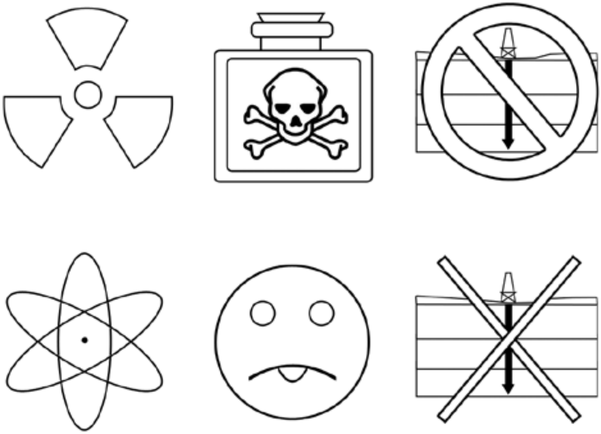


Figure 17: Warning pictograms and ideograms.

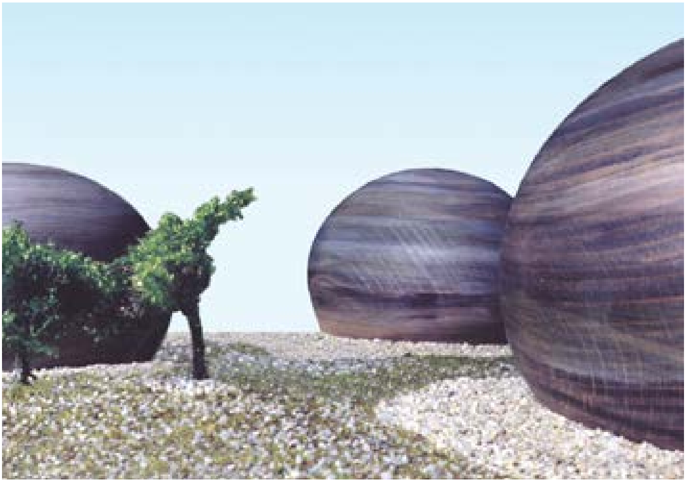


Figure 18: ‘Atomic eggs’, an early 1990s model for storage of radioactive waste.

IX Memory preservation and long-term stewardship

Our modern societies have recognised the need to preserve contemporary knowledge over generations. Various alternatives for transferring information over time were thus examined. In this context, the 1990 book *Warnings To The Distant Future* is the first attempt to consider the complex issue of atom semiotics and marking,[29] also described in the report *Ten Thousand Years Of Solitude?*,[30] not only from a holistic perspective but also from a controversial one.

Key findings from this debate have had an impact up to the present day. One option deals with the future role of institutions in passing information onto future generations and ensuring the protection of the population over long periods of time. The 'guardianship of waste' is being replaced by the 'guardianship of knowledge' over decades. Following the zeitgeist of the years of nuclear awakening with a growing community of 'believers and supporters', the pro-nuclear alliance was convinced that it could play the role of knowledge-bearer for all times. The Faustian bargain of the nuclear community led to the justification of an 'atomic priesthood',[31] a priesthood that was seriously questioned. Other views endorsed this vision with a similar mandate to an entity responsible for the long-term transmission of information on repositories – a proposal that earned harsh criticism from nuclear opponents and was even questioned by many semioticians.[32] However, an uncomfortable question was raised and still remains topical: *How do we warn future generations against our high-risk waste?* New models and terminology on ways to ensure cross-generational safeguarding and securing of the memory process were proposed. Some authors suggested 'news guards', others talked about the 'happy few' bearers of knowledge about closed repositories.[33] Even a scientific variety of millennialism arose.[34] By contrast, others proposed a relay system to be implemented every hundred years or so. In the last fifteen years, the scientific community has tended to favour such a relay system, a so-called 'long-term stewardship' (Figure 19).[35]

But can knowledge and memory really be transferred from one generation to another? What are the lessons learned and what is the knowledge gained with regard to structures from the past surviving over very long periods?

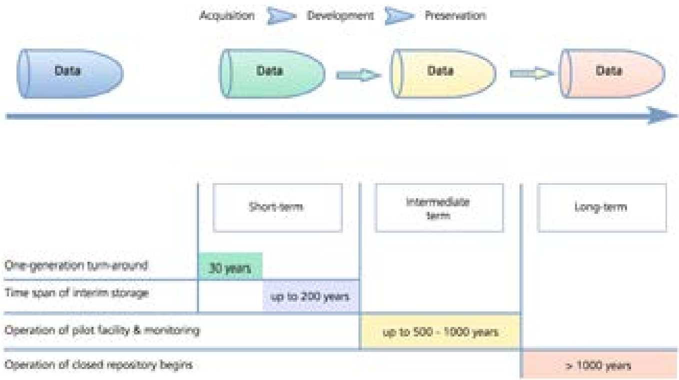


Figure 19: Long-term stewardship, the example of data transfer.

Can methods and approaches on how to ensure sustained stewardship over administrative and safety structures for long-term monitoring be derived from past experience at all, or are we better off with our own theoretical considerations? What are the challenges and risks for the relay systems? Can we really link long-term memory to stewardship over such long time spans? The task is colossal and still lacks a basic outline.

The debate among scientists and the nuclear community repeatedly proposes that institutions like the Vatican or monastic orders should assume the task of providing evidence for structural longevity and continuity. However, these examples are a poor choice and can – especially in terms of ensuring continuity – easily be disproved. Communities, especially those with ideological content, are rather prone to change, as illustrated by numerous historical examples. The creation of solid social structures presumes the development and implementation of normative rules and cultural codes. The implementation of such norms and codes over time by a specific institution requires canonisation of information and hence of language, form and content. And this is exactly where long-lasting religious institutions, such as churches, experience problems, since the canons and codes are likely to be outdated by the time they are transferred to a new value system. Conveying of information through millenary structures is thus doomed to fail.

Technical infrastructure, on the other hand, may provide a far more reliable and successful way of implementing the required tasks, as they are specialised in archiving, in water supplies, care and maintenance of dams, bridges, aqueducts or the management of forests. Good historical examples document the continuity of action in difficult situations and the longevity of technical institutions. Spectacular examples are the Cloaca Maxima in Rome, which is at least 2,500 years old and still in operation, the water supply of Eupalinos in Samos, and all the Greek, Roman and Arab aqueducts, which fulfilled their service over thousands of years. They bear witness to the fact that at least some essential infrastructures can be continuously maintained and preserved for very long periods (Figure 20). They may therefore be good examples revealing that cultural heritage can be associated with a task that sets its goal to protect future generations from these waste materials.

In addition, models have been discussed that can be used to persuade local communities to carry out the tasks of information transfer to subsequent generations. Currently, steering committees at the US Department of Energy and at the Nuclear Energy Agency of the Organisation for Economic Cooperation and Development (OECD) are developing strategies for an active, socially supported relay system that involves local communities.[36] But any approach requiring regular recoding of information bears the risk of erroneous coding and loss of information. Furthermore, procedural methods have been highlighted with regard to which part of this information could possibly be transmitted by rituals, legends, myths, and folkloristic events.

Figure 20: Roman aqueduct at Pont du Gard, France.

X
Outlook

These considerations lead us back to the succinct reflections of Hans Jonas and Günther Anders, arguing that our society should recommit itself and be held accountable for its actions. However, the task that presents itself to us, and to the hundreds of generations that will come after us, is enormous considering the mountains of toxic waste created by industrial society. This task unquestionably forms part of a cultural and intellectual development, which is very gradually emerging and which understands that there is no absolute 'free pass' for social action. We will only be able to sustainably use industrial resources when there is a widely recognised social duty to take responsibility for the long-term effects of the risks and hazards we are now imposing on future generations.

With regard to radioactive waste, this equation does not apply. Based on the current state of science and technology, it is almost impossible to follow a path other than to banish this long-term hazardous waste from the environment. However, we are facing a real dilemma. Not only do we have to protect the people from the repositories, but we also have to protect the repositories from people.

We will probably have no other option than to develop the best possible stewardship in the form of marking systems designed to protect mankind in the future. This plan will at least appease our conscience. Nevertheless, the contingency of uncertainty of such programmes remains. The present undeniably holds the yarn of the future. But nobody can say for certain how that tapestry will turn out.

About the Author

Marcos Buser (1949, Basel) is a geologist and social scientist, who has worked in the field of nuclear and chemotoxic waste disposal for over forty years throughout Europe, both as an expert and as a member of several governmental expert commissions. Since 1997, Buser has focused on the underground storage of hazardous waste in former salt mines. As part of his research, he has raised questions about the influence of business interests on the design of environmental legislation and regulation. In 2012, he publicly criticised the Swiss energy department for its less than rigorous implementation of the nuclear waste disposal programmes, upon which he resigned from the government's supervisory board, the KNS (Federal Nuclear Safety Commission). He is currently managing an independent research and consultancy firm, the *Institut für Nachhaltige Abfallwirtschaft* (Institute for Sustainable Waste Management), in Zurich.

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Endnotes

[1] L. Annaeus Seneca, *Naturales quaestiones* iii 26 (5-8): "In the Carian Chersonessos there is a fountain … which at long intervals sends up from its depths certain foul excretions of mud, until it is set free of them by being cleaned out. At certain places wells throw up not merely mud but also leaves, and bits of crockery and any other filthy things that have accumulated in them. The sea does the same everywhere, its nature being to drive ashore all filthy impurities. In the neighbourhood of Messana and Mylae, as it boils and tosses in storms, it throws up on the beach something actually like ordure, which has a vile smell too." (Translation J.W. Basore, Delphi Classics 2013).

[2] Gamma-hexachlorocyclohexane, a potent carcinogenic pesticide, present in many chemical dumpsites around the world.

[3] See the 2014 NEA/RWM report *Preservation of Records, Knowledge and Memory across Generations (RK&M). Loss of Information, Records, Knowledge and Memory – Key Factors in the History of Conventional Waste Disposal,* Nuclear Energy Agency, March 2014; http://www.oecd-nea.org/rwm/docs/2014/rwm-r2014-3.pdf.

[4] Strasser, J. and K. Traube, "Technik und Herrschaft", in Jokisch, R., *Techniksoziologie*, Frankfurt: Suhrkamp 1982, 242-334.

[5] *I.e.*, the release of greenhouse gas methane into the atmosphere through livestock.

[6] Bury, J.B., *The Idea of Progress, an Inquiry into its Origin and Growth*, London: McMillan 1920 (http://www.gutenberg.org/files/4557/4557-h/4557-h.htm).

[7] Sorel, G., *Les illusions du progrès*, Paris: Rivière 1911.

[8] *Journey to the Safest Place on Earth*, Production: Mira Film GmbH, Director: Edgar Hagen. 100 min. documentary 2013 (http://www.journeytothesafestplaceonearth.com/en/).

[9] Eduard Kiener, in Schweizerische Energie-Stiftung, *Atomgesetz-Revision durchleuchtet - ein Hearing,* [n.p.] 1979, 88.

[10] See above, note 3.

[11] The clean-up from a potential leakage of the Hanford reactor at Columbia River (WA), active between 1943 and 1970, was estimated in 2013 to have cost over $150 billion (http://en.wikipedia.org/wiki/Hanford_Site). The Kyshtym disaster at the Soviet plutonium production site of Mayak, 1957, was the third most serious nuclear accident ever recorded (http://en.wikipedia.org/wiki/Kyshtym_disaster).

[12] Burial, see: Alley, W., and R. Alley, *Too Hot to Touch, the Problem of High-Level Nuclear Waste*, Cambridge: Cambridge University Press 2013, 52, 62, 133 ff.; seepage trenches, see: de Laguna, W., *et al., Evacuation des déchets liquides de haute activité dans des bassins d'infiltration; données nouvelles,* Actes de la deuxième Conférence internationale de l'énergie atomique à des fins pacifiques, tenue à Genève du 1 au 13 septembre 1958, 23-51.

[13] For ocean dilution, see already Glueckauf, E., "Le problème à longue échéance de l'élimination des déchets radioactifs", in Nations-Unies, *Actes de la Conférence internationale sur l'utilisation de l'énergie atomique à des fins pacifiques* (Genève 1955), 1956; for dump, see: Milnes, A.G., *Geology and Radwaste,* London, Academic Press 1985, 46-48, Fig 16.; for an overview on disposal practices, see: Buser, M., *Hüte-Konzept versus Endlagerung radioaktiver Abfälle: Argumente, Diskurse und Ausblick*, Expert report for the Swiss Federal Nuclear Safety Inspectorate 1998; http://static.ensi.ch/1411388694/huete-konzept-98-scn.pdf.

[14] Philbert, B., "Beseitigung radioaktiver Abfallsubstanzen in den Eiskappen der Erde", in *Schweiz. Zeitschrift für Hydrologie*, 23/1961, 263-284.

[15] Ford, D., T.C. Hollocher and H.W. Kendall, *The Nuclear Fuel Cycle*, Cambridge, Mass.: Union of Concerned Scientists 1974. Space disposal is not seriously considered any more, given the accidents with space shuttles *Challenger* (1986) and *Columbia* (2003).

[16] Lucian, *Philopseudes* 34-36, see http://de.wikisource.org/wiki/Der_Lügenfreund_oder_der_Ungläubige. Goethe uses this motif in his ballad "The Sorcerer's Apprentice" (1797), as well as Walt Disney in his animated film *Fantasia* (1940).

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[20] Jonas, H., *Das Prinzip Verantwortung, Versuch einer Ethik für die technologische Zivilisation,* Berlin: Suhrkamp 1984, 64, 199 ff.

[21] *Ibidem*, 63.

[22] Anders (cited above, note 19) München: Beck, 1984, 96 ff. The 'Promethean gradient' or 'Promethean gap', called after Prometheus who, in Greek mythology, stole fire from the gods and put into motion human technological development, is the discrepancy between manufacture and imagination.

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[24] See http://www.swissinfo.ch/eng/dumping-grounds_communities-cope-with-serious-contamination/38134858 (14 March 2013).

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