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CAPACITY BUILDING IN SOLID WASTE MANAGEMENT & ENGINEERING FOR ACHIEVING THE MILLENNIUM DEVELOPMENT GOALS

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Abstract

In addition to genuine political will and availability of financial resources, achievement of Millennium Development Goals (MDGs) depends on the capacity of the people and organisations involved. If we rely on formal education to build capacities and thus contribute to the achievement of MDGs, this education has to be different from what it has been until now. (Engineering) education cannot remain limited to imparting technological knowledge only, while people are seen as a hurdle to acceptance of grand engineering schemes. Equally, management skills taught cannot be just a 'box of tricks', stripped of profound interest in the people concerned. The author believes that education ought to impart genuine interest in and compassion for fellow human beings and the world as we know it. Only then a significant improvement can be achieved in the living conditions of urban slum dwellers and population at large, poverty eradicated and environment preserved.

As a Senior Lecturer in the subject of Solid Waste Management and Engineering at an institution of tertiary education, the author of this paper presents some experiences in relation to achieving United Nations Millennium Development Goals. A bibliography of background reading is supplied.

1. Introduction

1.1 How is solid waste related to the MDGs?

Although not explicitly mentioned in the UN MDG targets, solid waste, if not adequately handled, can have very detrimental effects on human health and the environment and thus impair development. For example, in its MDG progress report, China states that: 'Urban solid waste, including hazardous waste, is putting increasing pressure on China's limited capacity for proper treatment and disposal, and is thus further polluting the urban environment.'²¹

Furthermore, generation of solid waste is closely linked with consumption, which in turn is one of the key issues of sustainability and (depletion of) environmental resources.

Therefore, the issue of solid waste may be placed under each of the three targets of the Millennium Development Goal no. 7, 'Ensure environmental sustainability', under which, among others, issues of sanitation and living conditions in slum areas are addressed.²⁰ This Goal can, in turn, have significant impact on achievement of other Millennium Development Goals. Illustrative is the list of positive effects of water supply and sanitation on other MDGs, provided in the '*Resource Pack on the Water and*

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Sanitation – Millennium Development Goals by Water Supply and Sanitation Collaborative Council.²⁶ The provision of safe water supply, adequate sanitation service and hygiene education represents an effective health intervention that reduces mortality.²⁴ Access to water supply and sanitation is a key factor in improving health and an essential component in alleviating poverty. It can be stated without exaggeration that access to water supply and sanitation is vital for people's health, dignity and development. Effective, affordable and environmentally sound approaches to dealing with solid waste certainly have their place in achieving these noble goals.

1.2 How is capacity building related to MDG 7?

Political will has been recognised by the Water Supply and Sanitation Collaborative Council as perhaps the most critical issue in efforts to achieve the UN MDGs and sustainable development in general.²⁶ Similarly, poor governance was identified by the UN Millennium Project team as the first of four most important reasons why countries are falling short in achieving the MDGs.²³

Substantial financial resources are, obviously, necessary as well. Several studies have been made to estimate financial requirements for achieving MDGs.^{5, 8, 9, 23} Here it should be noted that allocation of financial and other resources – for example in warfare rather than in welfare of the people – is also a matter of political decision.¹⁶

Provided that the genuine political will and adequate financial resources are present, the successful formulation and implementation of development programmes depend upon the capacity of countries, their institutions and their people. Capacity is the sustained (and sustainable) ability of individuals and organisations to perform their functions effectively and efficiently.²² Capacity building comprises:¹

- creation of an enabling environment (with appropriate policy and legal frameworks),
- institutional development (including community participation), and
- development of human resources.

Human resources include, among others, engineers at post-graduate level – Masters of Science. UNESCO-IHE Institute for Water Education is an international institution of tertiary education that offers Masters Programmes for engineers in water-related fields. Many of our former students hold high positions in their countries and thus directly contribute to development.

As a Senior Lecturer in the subject of Solid Waste Management and Engineering at UNESCO-IHE, the author of this paper presents some of her experiences and those of her solid waste management colleagues in relation to achieving the UN MDGs.

2. Our approach

UNESCO-IHE has a prominent role in strengthening and mobilising the global knowledge base on water-related issues. Our students come from Africa, Asia and Latin America; they usually have engineering background and affiliation with public service providers. The subject of Solid Waste Management and Engineering is offered within the MSc Programmes of Municipal Water and Infrastructure and of Environmental Science and Technology. We also give short courses in Delft and abroad.

In our subject, we attempt to address all three domains of sustainability: environment, society and economy. In our work, we 'see the economy as part of the environment, rather than the environment as part of the economy'.¹⁹

The curriculum of our subject has been developed following the dimensions of Integrated Sustainable Waste Management.⁷

- *Elements* of a solid waste management (SWM) system: technological measures that can be applied to solid waste in order to reduce its adverse impact on human health and the environment, including resource recovery;
- (Non-technological) *Aspects* of a SWM system: economic arrangements necessary to sustain effective and efficient functioning of a SWM system; various societal issues such as public awareness and participation in environmentally sound practices, legislation in force, institutional framework, planning;
- *Stakeholders* in the system, including the informal sector, their respective roles, fields of influence, responsibilities and limitations.

We teach by explaining principles, by giving numerous examples from developing countries to which the students can relate, and by triggering discussions and exchange of experiences. We do not have all the answers and we do not pretend to have them; instead of teaching *solutions*, we attempt to teach critical and analytical *thinking*, in a joint quest for most appropriate solutions in individual situations.

2.1 About technology

Getting acquainted with, and indeed mastering, technologies available for treatment of solid waste, including various resource recovery options, is essential for enabling our students to make the correct choices regarding the most suitable options for management of solid waste in their countries. This is even more important in their dealings with foreign consultants who often claim to have solutions even before getting acquainted with the problem at hand.

In this context, we find it very important to provide a clear understanding of the *governing principles* utilised in various technologies. This is because technologies are often presented in the form of glossy folders offered by the manufacturers of these technologies, which, by virtue of their very purpose of advertising the products, do not provide the complete information required for a fully informed decision. For example, in a number of cases, instead of opting for expensive, vulnerable and difficult to install synthetic landfill liners (geomembranes), an appropriate combination of locally available clays could potentially be used, exploiting their natural attenuation characteristics, to achieve an even better degree of environmental protection, as they can attenuate migration of contaminants by both advection *and* diffusion.¹⁵ Furthermore, whereas clays used as liners in containment systems have to be compacted to very low values of hydraulic conductivity of $K \leq 10^{-9}$ m/s according to regulations (which is very difficult to accomplish under field conditions), clays in attenuation systems need not be (and should not be!) compacted to such low values of hydraulic conductivity, as the optimum range is between 10^{-8} and 10^{-6} m/s for clays to exert their attenuation capacity.²

With regard to teaching technologies, we think that it is necessary to provide information on the *entire range* of the technological possibilities currently available to tackle the problem of solid waste, such as segregation at source, reuse, recycling, composting, collection, transfer, transport, incineration and disposal. As students are often familiar with one technology or the other, depending on the source of information they encountered in their practice (usually, these sources include contacts with consultants and involvement in international projects), we attempt to provide a comparative assessment of the all the available technologies. So we teach *assessments into situations* where the application of each of these methods is most appropriate, including criteria such as type of waste, climate, operation and maintenance requirements, financial feasibility, culture and public acceptance. To illustrate, the following is a typical example. From a process-technological standpoint, incineration *may* be a very appropriate management option for waste management in large cities. Nonetheless, if we want the local incineration plant to perform as desired, an array of conditions must be fulfilled, including waste properties, financial viability, as well as technological operation and maintenance requirements. These conditions are often omitted from consideration and local officials in a low-income country are left unprepared to cope with running of such a high-tech installation. In such a way very expensive incineration plants were built in a few large cities in low-income countries and were closed due to

malfunction shortly after the festive opening. In addition, the loans taken to build these installations had yet to be paid back.

2.2 And now something completely different: non-technological aspects

Non-technological aspects have proven to be crucial in determining the success or failure of major investments in technological solutions.^{10,17,18} Many infrastructure projects in developing countries have failed to deliver the expected benefits. Most failures can be attributed to inappropriate technology selection, lack of community participation and mobilisation, and insufficient attention to operation and maintenance issues.²⁵ Contrary to what might be expected, even in economically developed countries non-technological factors have proven to play a major role in determining the performance of technological measures applied in solid waste management.¹³ This is arguably even more pronounced in low-income countries. Issues such as the presence or absence of participatory governance, the roles and strengths of civil society organisations, minority and gender issues, degree of poverty, institutional arrangements (e.g. organisation of solid waste management in a community, degree and nature of the involvement of the private sector in provision of services), existence and suitability of pertinent legislation as well as the degree of law enforcement, all exert major influence on the services. In addition, political culture and the attitude to observing the law affect the performance of a solid waste management system.

It is worth remembering that even the key terms of solid waste management, *waste* and *hazardous*, do not have an intrinsic meaning that can be objectively determined, free of its social context. Rather, defining these terms is a political process in which several distinct factors interact, in addition to the scientific knowledge on the innate properties of materials. These factors include: the regulatory and administrative purposes which the definitions are to satisfy, viability of implementation, economic implications, pragmatic necessities, institutional structure, (political) culture, etc.⁶

For these reasons, non-technological aspects are amply represented in the teaching materials so as to equip students with the sensitivities required for societal realities, thereby enabling them to select and put the most appropriate solutions into practice.

2.3 Good governance

Considering non-technological aspects along with technological options is particularly important in cases of projects involving foreign loans and donations, as the failures may be very costly, both in terms of (scarce) financial resources and public trust and credibility. These projects are usually a result of bilateral agreements on development assistance either from individual economically developed countries or from international financing agencies. Frequently, such projects have negative overall effects for the recipient country. Imported solutions may not match the local conditions or the recipient communities may become dependent on foreign expertise and technology supply. The reasons for this include:

- Failure to consider local conditions under which equipment is intended to function, such as type of waste, local availability and the difficulty of obtaining spare parts from abroad, availability of people with necessary skills;⁴
- Promoting equipment manufactured by the donor country's industries, regardless of suitability of the equipment to local situation;
- Political pressure exerted on mayors, department managers and engineers in low-income countries to accept aid, regardless of whether they perceive it as helpful or not;⁴
- A lack of knowledge on the part of local officials;
- Decision-makers' preference for modern and sophisticated technology regardless of its applicability;
- Favouritism practices (i.e. choices motivated by personal gains) prevalent in some low-income countries.¹²

We find it important to address such practices in an explicit manner, so that the students realise the significance of taking some seemingly minor issues along with the costly technologies into the overall decision.

2.4 Risks

Even though at present most (international) financing agencies and national legislations require environmental impact assessments to be done for most solid waste management facilities, we do not expand on this topic, as it is addressed in other, dedicated subjects. Nevertheless, we attempt to impart to students thinking in terms of risks, so as to place all technologies in the perspective of protection of human health and the environment. We explain to them how the entire discipline of solid waste engineering has evolved since 1970s, when cases of adverse health effects in the vicinity of former waste dumps occurred in industrialised countries. In response to the remarkable publicity these cases received, and the subsequent outcry from the general public, and in recognition of the possible problems with (hazardous) waste, politicians adopted policies and enacted laws on waste management practices. Laws were translated into requirements for solid waste facilities, which prompted researchers and engineers to develop the various technologies as we know them today.

We find it very important to introduce notion of uncertainty and discuss decision-making about risks, in the framework of environmental monitoring and standards.

Finally, we also address to some extent issues of (environmental) justice and equity as very relevant to sustainability, based on the example of export of waste for recycling from developed to economically developing countries.^{3, 14, 16}

3. Experiences

3.1 Knowing waste is important

In general, both students of our MSc Programmes and participants of our short courses are very eager to learn, they actively participate and are very enthusiastic.

Our students usually have previously made acquaintance with some individual technologies for solid waste management (SWM), depending on their experiences with foreign consultants or international research projects. We find it important to provide an up-to-date account of the state of affairs and thus teach the full range of technologies applicable to solid waste. Still, unsurprisingly, in our visits abroad, we often find that people who get a job in the solid waste department of their municipalities are sometimes unfamiliar with even the basic terminology of their job, let alone the details and the tricks of the trade.

Our students have very little prior understanding about criteria to be applied in determining the appropriateness of various technologies. They seem to be particularly surprised at the importance of waste characteristics for choice of appropriate technologies.

They mostly do not have prior knowledge of integrated sustainable waste management nor any idea about (the importance of) strategic planning, and appreciate very much learning about them. Public servants in charge of municipal solid waste collection services are so accustomed to 'fire-fighting' in their day-to-day allocation of equipment and staff, that they lack any overview of the entire system or prospect for a significant improvement. Equally out of their sight is the informal sector, which often provides very valuable complementary services to the community. We argue that, even under circumstances of inadequate financial resources, the system would benefit from gathering basic information and introducing strategic thinking about co-ordination of activities and distribution of responsibilities among stakeholders and the consequent optimisation of resource allocation.

In cases where some financial resources are made available, implementation of plans is still a very big problem, due to lack of capacities in local human resources. These plans are often prepared by foreign consultants, without any significant involvement of local staff to speak of, and therefore without a strong capacity building component. We know of a long-term project where a European country had been involved in establishing legislation and National Master Plan for solid waste management in an African country, and some ten years down the road finally realised that some form of capacity building for local practitioners would be needed.

Our students often lack understanding of environmental monitoring and legislation. They know amazingly little about the process of setting standards, which they (have to) apply in their day-to-day engineering practice, particularly about its political nature and societal context. Their trust in science, their lack of insight into scientific method – and its limitations – often border on dogmatism. Therefore we find it very important to introduce the notion of uncertainty and discuss decision-making about risks.

Interestingly, in our encounters in the field, it happens rather frequently that decision-makers and engineers in charge alike omit to consider the financial sustainability of private sector involvement in municipal services. Somehow, involvement of private sector tends to be seen as a universal remedy for all problems of inadequate and inefficient services whereby realities of the financial framework (e.g., type of fee, degree of fee collection, affordability of the services) seem to be ignored.

3.2 Love of hardware

In general it can be stated that we first have to make students aware of the necessity to take *all* the elements into account, considering an array of non-technological issues as well as the technological aspects that often first come to their minds. We emphasise that addressing the society-related issues is indeed absolutely essential for providing viable, lasting solutions. This implies that we have to 'break' the illusions students might have had regarding the omnipotence of technological solutions.

Perhaps due to their engineering background, our students tend to focus on technological aspects only. They prefer clear-cut engineering solutions, calculations, design exercises, rather than engaging in comprehensive consideration of the societal framework where their technological solutions are to function. Some strongly protest if we insist on non-technological aspects. They also do not seem to appreciate possible inputs by social scientists, nor regard it as equally valuable as engineering. (Apart from a limited number of individual cases, I do not have insight into how social scientists regard engineers!)

I believe that this has to do with their previous education (undergraduate studies) that is technology-focused, where no attention is given to 'soft' issues and no sensitivity to such issues is imparted to students.

Since we get to select participants for our short courses, we do that on the basis of their direct involvement with solid waste management. Consequently, these participants usually have some practical experience and are thus more aware of significance of non-technological issues, and are more enthusiastic to learn about them further.

Our experiences in this regard are confirmed by the results of a preliminary needs assessment study we conducted to assess the need for professionals in engineering fields related to the MDG target 10 on water supply and sanitation in Africa, Latin America and Asia.^{10, 17} Data were gathered by interviewing selected respondents from various stakeholders in representative countries. A recurring message from respondents was that engineers lack understanding of social realities and knowledge about management and legal aspects. Furthermore, undergraduate students are insufficiently exposed to day-to-day practice in their engineering field. Additionally, curricula and research on appropriate technological solutions are insufficiently adjusted to local needs and circumstances. Respondents

pointed to the lack of co-ordination of activities and lack of co-operation among stakeholders involved. An ever more prominent role of non-governmental organisations (NGOs) is recognised.

Analysis of several water supply and sanitation projects in Asia revealed that about 20% of professional input is needed for community mobilisation, in order to ensure the success and sustainability of projects.¹⁷

3.3 Stop working, start thinking

Against their better judgement, students tend to expect a set of ready-made technological solutions that they can directly apply upon their return home. Regular students and short course participants alike are usually not aware of the need for a well-structured, comparative analysis and critical thinking in order to come to sound decisions.

We find that it is an integral part of our role and responsibility as a teacher to impart this analytical and critical thinking.

In broadening graduates' horizons and building confidence, their access to up-to-date information and insights could play a significant role. Many of them, however, have not had a chance to master the skill of searching for, finding and selecting relevant information from the abundance of available sources on the Internet. Critical thinking is here also the decisive factor. (Additionally, though constantly improving, access to Internet is not yet universally and conveniently available worldwide.)

As our students actively take part in discussions and express their opinions – the act of which often requires an effort to overcome their cultural backgrounds – we had assumed in the past that our graduates, when equipped with knowledge and insights, would develop sufficient confidence to put forward their arguments in a decision-making process in their home countries or challenge the opinions of eloquent foreign consultants. However, we have noticed, particularly in individual guidance sessions, that students usually need more explicit encouragement and support in building confidence.

Furthermore, I believe that we should attempt to give 'guidance (to students) in their search for ethical and responsible ways to live and act', to convey the message that we need to act as citizens of the world.¹⁶

3.4 Tertiary education in solid waste management

As a relatively new branch of engineering, solid waste management has seldom been taught in regular courses at universities. In other words, until recently, there has been hardly any formal education on this subject. Perhaps, as an illustration, it could be mentioned that an Internet search has resulted in only three universities where a Master of Science Programme in solid waste management is offered, (at the University of Illinois at Urbana-Champaign, USA, the University of Stuttgart, Germany, and Wageningen University, Netherlands). A word of caution would be in place: while these programmes undoubtedly are laudable academic endeavours and perfectly suited to the needs of the host (industrialised) countries, they could potentially have adverse effects and lead to inadequate solutions if indiscriminately copied in developing countries. A number of institutions of tertiary education in developing countries, including Asian Institute of Technology in Thailand, provide courses in various aspects of solid waste handling. It would be very interesting to make a comparison of curricula among these institutions.

It would be equally interesting to learn how much of the what the students learn at university is actually applied back home. We would be very happy to perform – or obtain results from – an in-depth analysis of the possible obstacles. On an anecdotal note, we had cases of participants on our short courses who had to lie to their superiors about ill relatives in the countryside in order to get leave to attend a course.

In the future, we would like to introduce relevant sustainability indicators into our lectures on various aspects of SWM, and to broaden the topics of our research. We co-operate with colleagues from other departments for joint research into sustainability in our education. In addition, we would like to address the environmental sustainability of various management options for solid waste.

Although relevant publications on similar issues can be found in *Journal of Cleaner Production* and *International Journal of Sustainability in Higher Education*, there are far too few publications from developing countries. Also, at the international conference *Engineering Education in Sustainable Development* there were very few representatives of universities from Africa, Asia and Latin America.

3.5 I am fine, thank you; how about the rest of the world?

From students' responses to our triggering discussions, it is evident that the issues of ethics, international relations, legacies of colonial times and attitudes occupy their minds. In this arena, we as teachers must make a decision. Do we take the stance that engineers are problem solvers, and that scientists are detached spectators of life, or should we talk and act in the belief that we all, regardless of our professions, are actors and creators of the world around us in the literal meaning of the word? As engineers, do we merely engage in solving the problems set out before us (notwithstanding the extent and complexity of these problems) or do we also endeavour to transform or prevent the problems? In our pursuit of the principles of engineering excellence, in what way do we regard those for whom the results of our work are intended? Do we genuinely care about them?

I would argue that our educational systems are heavily biased towards developing qualities of intellect only. Qualities of heart – or even spirit – are completely neglected. I submit to you that, if immense potential of human ingenuity were inspired by these qualities – compassion, genuine interest, sharing, and concern for the development of humankind – our efforts to preserve the environment and improve living conditions would surpass the Millennium Development Goals.

4. Conclusions

In the search for appropriate solutions to problems in solid waste management, capacity building is most successful if focused on an integrated and sustainable approach. This approach involves a balance between technology and societal framework, entailing an array of non-technological aspects.

The extent to which sustainable development, or better yet, sustainability of life, is incorporated into the educational system is the measure of the quality of that education.

It is evident that the educational institutions (can) have a critical role in forming the attitudes and worldviews of students. Currently, education in many countries is focused on information. This is very inadequate. Educating intellect ought to entail effective development of the capacity for critical and analytical thinking.

Nonetheless, focus on the intellect alone is insufficient to address current issues of the world. Only if our intellectual endeavours are inspired by qualities of heart, by genuine interest in and compassion for human condition and that of the world, will our solutions bring lasting improvement for people around the globe.

In the face of the numerous challenges confronting humanity today, teachers of engineering subjects cannot keep a neutral, valueless stance. The times call for commitment and action on the part of students and teachers alike, the stance that we are not a neutral spectators or merely problem-solvers, but responsible citizens of the world. It is time to change the paradigm of education.

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