Evolving the Theory of Waste Management: defining key concepts

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Abstract

The Theory of Waste Management represents a more in-depth account of the domain and contains conceptual analyses of waste, the activity upon waste, and a holistic view of the goals of waste management. Waste Management Theory is founded on the expectation that waste management is to prevent waste causing harm to human health and the environment. The proper definition of waste is crucial to constructing a sustainable agenda of waste management. It is largely the case that current legislation attends to existing waste. Definitions emerging from this condition may, however, conflict with the goals of waste prevention, because something that already exists cannot be prevented from arising. When material is assigned the label of 'waste', it will be treated as such; consequently, despite its explicit wish of waste prevention, implicitly, legislation essentially amasses waste. The inherent philosophical implication of such definitions is that they are not able to facilitate a sustainable waste management system. Therefore, new, dynamic definitions for waste and waste management must be sought, which can explain why waste is created and can offer an intrinsic solution for the problem. A radically new approach, based on an object-oriented modelling language, is presented to define the key concepts of waste management.
Keywords: Theory of Waste Management, waste, non-waste, waste management, definition, theory, purpose, structure, state, performance.

1 Introduction

There is a clear distinction drawn between using the word 'theory' in the scientific domain, as opposed to everyday life. In common usage, 'theory' is


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contrasted with 'practice.' The word 'theory' is associated with a feeling of uncertainty. Propositions are apt to be termed theories, because their truth is not certain. In the philosophical sense, the relationship between theory and practice is rather different. The word 'theory' originally means to observe, or to contemplate. Theory, in its origin, is the state of contemplation as distinct from the state of action [1]. With the help of scientific research, we try to explain and comprehend the facts and regularities of nature, humans, and their society [2].

It is fashionable to speak of modern, Western culture, as existing in the science and technology era. While there is some rivalry between these two, they meet in scientific research at one end, and in engineering design at the other end. Scientific research results in scientific laws and theories, while the implications of engineering design are buildings, machines, systems, etc., intended to function according to the objectives they were designed for [3]. Niiniluoto argues that present scientific development has developed in such a way that the number of technical applications of science have increased, while the theories themselves are becoming more and more abstract, reaching beyond everyday experiences [2]. Most who have written – and write – about theories and cognitive reasoning, are from the fields of empirical sciences, or the philosophy of science. However, new scientific specialities emerge from previously practical fields – witness the Middle Ages, whence the techniques that separated the master from the amateur in the handicraft arts became closely guarded secrets of the guild.

2 Evolving theories of technology

Human beings have the cognitive ability to disregard unimportant or accidental characteristics, properties and relationships, and to emphasise the significant and important ones, in order to focus on the generic features of the perceived/observed piece of reality. Abstract conceptualisation, as a cognitive process, has helped humans to obtain knowledge in all areas; to group and classify it, and to provide it with suitable structure. Creating and expanding individual sciences and meta-sciences have resulted [4]. The uppermost human achievement is 'creating something new' that is of some potential benefit to mankind. That 'something new' includes artistic work, processes and products, or knowledge. Technology is full of instances where practice has preceded theory, and the subsequent development of theory has served to improve the practice [4]. A science passes through various stages of maturity from the description of phenomena, through categorisation, modelling and test of phenomena to quantification [6]. However, many areas of science cannot reach the final 'quantification' stage in which mathematical relationships are formulated [5].

Scientification of technologies follows a general pattern [2]: An activity requiring specific skills becomes a craft or profession. The skill is transmitted from masters to novices, but there will also be an attempt to formulate its content and rules of thumb, and to collect them into practical guidebooks. Such collections of rules may be based upon everyday experience or pseudo-scientific,

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'magical' and religious doctrines. A new science is born, when the effectiveness of such rules is tested by scientific methods and explained by scientific theories.

Constructing Waste Management Theory (WMT) is an effort towards scientification of waste management. WMT is a conceptual description of waste management, providing definitions of all waste-related concepts, and suggesting a methodology of waste management. It is an effort to organise the diverse variables of the waste management system as it stands today.

2.1 The significance of definitions in evolving theories

WMT is based on the hypothesis that the way we describe a target prescribes action upon it, which implicates that sustainable waste management depends greatly upon how waste is defined [7]. Every term used in a scientific theory or in a given branch of science ought to be precisely defined. Definition is the most obvious, and adequate method of characterising a scientific concept. Definitions are offered to state or describe the accepted meaning, or meanings, of a term already in use are called descriptive definitions. Descriptive definitions are of the form: *Definiendum* has the same meaning as *definiens* [8].

Definition is always important in the field of law, but it is particularly important in a system of regulatory control, as it is necessary to define what can and cannot be controlled [9]. Effective definition of core concepts is an epistemologically well-bounded theoretical construct [10]. It follows that a prerequisite of the scientification of waste management, and the evolution of WMT, is offering scientifically adequate definitions of the key concepts of waste management, starting with the descriptive definition of waste.

3 Defining waste – analysis of the concept of waste

The primary justification of regulating waste disposal was to regulate waste disposal [11]. However, the key to sustainable waste management is waste minimisation, in particular the reduction of waste at source [12]. The Sixth Environment Action Programme defines waste minimization as the priority objective of Community waste policy [13]. This dual objective of resources conservation and disposal policy results in the lack of clear definitions of key terms [11]. Opinions diverge sharply on the proper definition of waste [14]. Table 1 lists a selection of waste definitions. One method of defining waste is by a listing of activities or substances which come within the range of definition. An alternative technique would be to define by reference to the purpose of the regulation. Most regulatory systems adopt a mixture of the two techniques [9].

'Legal' definitions of waste, such as defined in points 1 – 3, are an example of such. The European Commission drew up a list of wastes belonging to the categories listed in Annex I: the European Waste Catalogue (EWC) [15]. The inclusion of a material in the EWC does not mean that the material is a waste in all circumstances; Article 1 requires the substance to be *both* listed in Annex 1 and be discarded [9]. Discard appears to be a key ingredient in defining waste. The word 'discard' has the connotation of rejection of something useless or

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undesirable. There appears to be a feeling of resentment within EU Member States, maintaining that waste collected for recycling purposes should be defined as a secondary raw material. On a number of occasions, legal disputes have been resolved in the European Court of Justice (ECJ); however, the ECJ held that a substance may constitute waste, even when it is capable of economic reutilization. Advocate General Jacobs argued in the Euro Tombesi case that the term 'discard' employed in the definition of waste has a special meaning encompassing both the disposal of waste and its delivery to a recovery operation.

Table 1: Various definitions of the concept of waste.

1	EU	Waste shall mean any substance or object in the categories set out in Annex I, which the holder discards or is required to discard [15].
2	OECD	Wastes are materials other than radioactive materials intended for disposal, for reasons specified in Table 1 [16].
3	UNEP	Wastes are substances or objects, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law [17].
4	Lox	Waste is either an output with ('a negative market') 'no economic' value from an industrial system or any substance or object that has 'been used for its intended purpose' (or 'served its intended function') by the consumer and will not be re-used [18].
5	McKinney	Waste is the unnecessary costs that result from inefficient practices, systems or controls [19].
6	Baran	Waste is the difference between the level of output of useful goods and services that would be obtained if all productive factors were allocated to their best and highest uses under rational social order, and the level that is actually obtained [20].
7	Hollander	Waste is something that needs to be expelled in order that the system continues to function [21].
8	Elwood & Patashik	Waste, like beauty, is in the eye of the beholder [22].
9	Gourlay	Waste is what we do not want or fail to use [23].
10	Pongrácz	Waste is an unwanted, but not avoided output, whence its creation was not avoided either because it was not possible, or because one failed to avoid it [24].
11	Pongrácz	Waste is a man-made thing that has no purpose; or is not able to perform with respect to its purpose [7].
12	Pongrácz	Waste is a man-made thing that is, in the given time and place, in its actual structure and state, not useful to its owner, or an output that has no owner, and no purpose [7].

What is common in definitions of 1 – 4 is that they interfere at the time when waste is to be moved from the place of its generation, they thus act upon existing

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waste. Waste management thus appears to be simply a reaction to waste. Here we can observe the conflict of the duality of waste policy: if we define waste at the point of its creation, how can we avoid its generation? Its utilization is hindered as well, since when defined as 'waste', recoverable material is seen more as a potential pollutant than as a potential raw material [25]. In Europe, industry has voiced serious concerns that definitions may become a barrier to an efficient and sustainable waste management system [26]. When material is assigned the label of 'waste', it will be treated as such. The uninvited consequence of such labelling is that something may end up *just* being treated as waste, that is, being discarded. Despite its explicit wish of waste prevention, implicitly, legislation essentially amasses waste [7].

McKinney and Baran (definitions 5 and 6 in Table 1) refer to waste as a result of the inefficiency of a system. In contrast, Hollander (def. 7) considers waste something that has to be extracted to achieve efficiency. The term waste derives from the Latin *uastus*, meaning to ravage, to leave desolate, or to fail to husband or cultivate [27]. Hence, of the varieties of waste, 'technical inefficiency' is probably closest in meaning to traditional usage.

The blithe reference to waste by Elwood & Patashik (def. 8) is noteworthy for its recognition of waste being a human-related value concept. This assessment seems to indicate that waste cannot have an objective definition. It follows that, rather than trying to define the material, referred to as waste, we shall analyse the activity that resulted in waste creation. Gourlay's definition (no. 9) embraces the idea of describing human activity, by pointing out the failure of human actions that resulted in wasting. Definition 10 is an effort to go a step further, and explain the reason of human failure; however, the full understanding of wasting was resulted by the analysis of the reasons of activities that lead to waste creation. The fundamental concomitant of this analysis is that, if we know the reason of wasting, we are able to devise action to prevent it.

3.1 Waste definitions toward sustainability

It has been realized earlier that there are four waste classes, collected in Table 2.

Table 2: Classes of waste [28].

Class 1	Non-wanted things, created not intended, or not avoided, with no purpose.
Class 2	Things with a finite purpose, destined to become useless after fulfilling it.
Class 3	Things with not acceptable performance due to a flaw in Structure or State.
Class 4	Things with acceptable performance, but their users fail to use them for their intended purpose.

The assertion is that this classification unambiguously categorizes every waste object. The categories also highlight wrongful action, and call for steps to correct it. When we describe waste of Class 1 (e.g. waste emissions) as 'a thing to which the producer has not assigned a Purpose', we indicate the error on the part of the producer. When waste of Class 2 (e.g. packaging) has fulfilled its

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purpose, we shall exhaust the possibility of assigning a new purpose (e.g. refill). If waste of Class No 3 is an item of waste, which is not performing in respect to its original Purpose due to irreversible damage in Structure' (a broken equipment), one can opt for a recovery alternative. Finally, the description of waste in Class No 4 as 'an object, which the owner failed to use for its intended Purpose' (leftover food being flushed down) emphasizes the fact that it was the wrongful action of the owner that created waste. The solution is increase awareness, to avoid waste, selling/donating the non-wanted thing (old clothes).

The taxonomy of waste in Table 2 was formulated using an object oriented modelling language, PSSP™, which is based on the ontological commitment that every real thing can be formalised as an object having four attributes: Purpose, Structure, State, and Performance [29]. Analysing the attributes of wastes, it was recognized that *waste is a thing that has no Purpose; or is not able to perform with respect to its Purpose* [7]. To some aspect, according to this definition waste *is* in the eye of the beholder, as humans assign Purpose and humans evaluate Performance. However, this description also allows for the possibility of the waste being turned into a non-waste, and emphasizes that being 'waste' is a temporary failing that needs to be remedied. It is argued that this definition describes every waste thing.

Following the European Commission's communication "Towards a thematic strategy on waste prevention and recycling", the Commission and Member States were gathered for a two days workshop in Leipzig on February 25-26, to discuss the classification of treatment operations and of the waste definition. One of the observations of the Leipzig workshop was that "using the definition of waste is a tricky affair when determining when something becomes waste and when it stops being waste." To the first situation belongs among others the placing of re-use, the application of the definition of waste to end-of- life vehicles. To the second belong for example treated construction and demolition waste [30]. Using the taxonomy of Table 2, all of these waste examples are possible to identify:

- Re-use generally applies to wastes of class 2. Take an example of a glass bottle, the purpose of which is to deliver soft drink. As soon as the soft drink is consumed, the bottle has fulfilled its purpose. However, it has the potential to fulfil the same purpose again: to contain, and deliver any liquid. A re-usable glass bottle is thus a non-waste, as long as it is returned for refill. Re-use is also subject to proper structure and appropriate state.
    - State is a measure of functionality, as state defines the ability of the material to perform work. E.g. state indicates the object's situation on its life-cycle: the older the material is, and thus closer to the end of its useful life, the less likely it is able is to perform its purpose.
- End-of-life vehicles are typically wastes of class 3. They are complex objects composed of several structural parts. The loss of performance can be attributable to the inability of one or several structural parts to perform their purpose. Repair, if applicable, that is, changing the faulty structural parts can extend the useful life of defective vehicles.

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  - Space and time affect this possibility; spare parts may not be available in the country of residence, or spare parts are no longer available at the time of need, because their manufacture has been discontinued.
  - In case of extensive repair need, eco-efficiency issues will have to be assessed. If the work, material, and energy intensity of repair surpasses the benefits, it may not be wise to pursue repair. It would be ill advised to keep cars with poor environmental performance on the road.
  - In case the owner abandons the car in a working condition, it would appear to belong to class 4. However, the owner might argue that while the car can perform its purpose of transportation, it did not meet all his expectations of performance, as e.g. its gasoline consumption was too high, and didn't offer the comfort expected, etc.
  - The human factor is very significant, as there might be another owner, who is willing to tolerate low mileage and the lack of amenities because of fondness his of old cars, or because he could not afford a better one.
- Demolition waste can be viewed as waste of class 2, one that has fulfilled its purpose. Incidentally, it may be originated from a waste of class 3, e.g. a house that was no longer performing satisfactorily and thus was disintegrated. If this treated demolition waste can be assigned a new purpose and its structure and state allows it to perform satisfactorily with respect to that purpose, it shall no longer be considered a waste.

The conclusion from this analysis is that simple manipulation of object properties is capable of turning wastes into non-wastes. However, it has to be recognized that, when defining the concept of waste, there are several dimensions to consider. Waste is a dynamic concept: the same thing can be waste or non-waste for different persons, in different places, and in different times. For this reason, it was finally concluded that *waste is a thing that is, in the given time and place, in its actual structure and state, not useful to its owner, or an output that has no owner, and no purpose* [7].

4 Defining waste management

The European Council Directive on Waste defines waste management as collection, transport, recovery and disposal of waste, including the supervision of such operations and after-care of disposal sites [15]. Being a descriptive definition, just as the definition of waste, waste management consequently should mean the 'collection, transport, recovery and disposal of objects that their holders discard.' Clearly, this definition suggests that waste management is merely manipulation of discarded things, waste management is thus activity upon material. The word 'management' actually indicates manipulation of activity, and it is argued that waste management encompass more than just merely treatment of waste. As illustrated in the previous section, turning wastes to non-wastes involved a number of applicable waste management actions. As it has been put forward earlier, waste management also entails strategic planning, prescribing options, prevention of the contamination of environment and

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conservation of resources, minimizing the amount and toxicity of waste creation. choosing the best treatment option, with taking into consideration legislation, assessing effects and consequences and decision making [7].

It has been suggested that waste management is to be defined [32]:
waste management is control of waste related activities, with the ultimate aim of resources conservation and protection of human health and the environment.

To be able to design the most appropriate waste management system, the proper theoretical background has to be established. WMT will have to be built, such that embraces the following notions [7]:

- Waste management is to prevent waste causing harm to human health and the environment.
- The primary aim of waste management is the conservation of resources.
- We shall avoid waste creation by creating useful objects primarily.
- Waste management is to encompass the goal of turning waste into non-waste.

5 Toward the Theory of Waste Management

As with any new theory, one should start with defining the scope of the theory, and define the core of its concepts. Waste management has to be planned within restrictive limits, where the choice of options is generally pre-specified. It is expected that the insight that the theory of waste management would give to the domain would greatly contribute to achieving the goals of waste management: resources conservation and environment protection. The practical values of Waste Management Theory thus are [7]:

- Giving answers to conceptual questions by explaining waste and concepts.
- Providing a guide for choosing waste management options.
- Providing a foundation for how and when to select and integrate waste management options.
- Predicting the outcomes of the use of waste management actions.
- Aiding legislation in how to prescribe activity for/upon waste.

6 Conclusions

The Theory of Waste Management, as differentiated from waste management practice, represents a more in-depth account of the domain and contains conceptual analyses of waste, the activity upon waste, and a holistic view of the functions and goals of waste management. In this article, a conceptual description of waste management was offered, providing novel, dynamic definitions of waste and waste management. It can be asserted that when one is looking for a scientific systematisation, and ultimately aiming at establishing an explanatory and predictive order among the domain problems of waste management, a theory is required. It is concluded that there is a need for more theoretical research to be made in the waste management domain, and to offer a scientifically founded and optimal choice of waste management options.

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