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Chapter 16

Substance Stories

Jens Soentgen

Substance stories narrate the social and ecological life of substances.[1] The notion designates certain processes in the course of which substances are produced, transformed, moved (or move by themselves) as well as a research method and certain types of narratives. As a research method, substance stories are a form of ethnographic and historical research. Often it is also spoken of "histories of things," in the English-language literature of the "social life of things." The ambivalence lies in the object itself; many histories begin with things (sugar beet for example) and end with substances (sugar) or vice versa (as in the case of crude oil, from which, for example, plastic products are made). The phrase "life history" is, from a modern point of view, a metaphor, if one refers to substances. We no longer believe that gold and other metals are living entities and slowly grow and ripen in the depths of the earth. Nevertheless, it must be taken into account that in other locations, in other places, in other cultures, there is indeed the assumption that substances are alive, that they breathe and have perception, even have a personality.

If modern scholars or writers narrate the "life of a thing" (or substance), they mean something different, that is, their "life among us," that is, the dynamic that *we* assign to them, whereby we make them an object of our societal interaction, whereby we produce, transform, exchange, or buy and sell, use, reuse, and discard them. It is human collectives that mobilize the substances. Nevertheless, it would be incorrect to proceed from totally passive entities that are "underway" only as long as they are moved by human hands or machines.

They are not only transported, but they are self-acting, that is, they also move and transform by themselves. And precisely this quality expands their societal life. Substances distribute themselves over the world: oil spreads out on the ocean, nitrogen fertilizer and pesticides diffuse into the ground water,

smog forms and distributes itself in cities, and so forth. This self-activity and automobility legitimize speaking of the *life* of a substance, besides the historical depth and complexity of the societal network of a substance.

THE BASIC IDEA OF SUBSTANCE HISTORIES

As an explicit methodological concept "substance histories" in a global, transnational sense arose for the first time in the context of a literature program according to the concept that the Russian futurist Sergej Tretjakow formulated in 1929 in his essay: *The biography of the thing*, a polemical discussion of the "classical novel" (Tretjakow 1985: 102, my translation). Instead of building on individual novel heroes, Tretjakow recommended authors "to build up the story as a type of 'biography of things'" (ibid.: 104). By "thing" Tretjakow meant, with the background of a materialistic philosophy, above all, substances: "books about wood, grain, coal, iron, flax, cotton, paper, locomotive, production plant are not yet written. We need them, and only with the methodology of the 'biography of things' can they be produced in a satisfactory manner" (ibid: 106). The compositional structure of the new stories drafted by him "allows a comparison with an assembly-line, on which the raw product glides along. It transforms itself into a useful product through human effort." Tretjakow followed the intention, through such novels, to make visible "the class struggle in developed form at all stages of the production process" (ibid.).

With this concept of literature, he found numerous followers. Many novels were published according to this pattern (cf. Soentgen 2013). Tretjakow himself refers to the novels of Pierre Hamp (1930, 1936) who, in his novel series *La peine des hommes* (*The Pain of Man*) in this spirit had dealt with flax and also seafood. The method should provoke, but also enlighten, as Tretjakow says: "The 'biography of things' is a very useful cold shower for the literati, [. . .] so that the writer [. . .] transforms himself into a person with a somewhat more contemporary education" (Tretjakow 1985: 105). The method, in its modern scientific usage, has freed itself from the materialistic background of Tretjakow. The basic idea, however, today can still be described as Tretjakow proposed it: the substance "is used as a mobile viewpoint of the different contexts lying on the route of the product" (Engel 2009: 28, my translation). The instructions of the anthropologist Arjun Appadurai, who has published the most important theoretical text on the subject up till now, has been summarized with the slogan "follow the thing!";[2] for "[f]rom a methodological point of view it is the things-in-motion that illuminate their human and social context" (Appadurai 1986: 6). In his famous study about sugar, the American anthropologist Sidney Mintz says: "I hope to explain

what sugar reveals about a wider world, entailing as it does a lengthy history of changing relationships among peoples, societies and substances" (Mintz 1985: xxiv–xxv). It is thus a question of not only focusing on limited details, but also to take into view the whole of the relationships, the plurality of the many action contexts that are relevant for substance histories.

PRAGMATIC AND SCIENTIFIC SUBSTANCE HISTORIES

First of all, the simplicity of the basic idea simultaneously stimulates the fantasy and the curiosity, for it is equally unusual and exciting to track a specific substance, a specific thing beyond frontiers. Many substances carry the researcher over long distances, their paths cross cultures, continents, and oceans. The researcher becomes a hunter, a tracker. Substance histories can be something of an adventure. If one seriously undertakes such an adventure, however, then one quickly notices that the substances are thoroughly unusual and unconventional tour guides. In the process, they do not only take on new names, they also transform themselves before our eyes.

Substance histories cannot presume a fixed, solid identity, neither with respect to the name, nor with respect to the concept, nor with respect to the "real" substance. Somewhat more technically formulated, neither the extension of the term, nor its intention, neither its reference, nor the contexts, can be presupposed stable. Even our fundamental conceptions of substances cannot be taken for granted as universally valid. Like other transnational methods of historical writing, the substance-historical method is quite a demanding approach (Pernau 2011: 7; see also 67–75) especially due to its continuous plurality—of terms, stories, worlds, and values.

The task is complicated if the work is to be done following academic standards. However, substance stories must not be academic; there are also pragmatic substance histories that serve clear political, economic, or didactic goals. Pragmatic substance histories have different construction principles (cf. Soentgen 2013) even if they might contain relevant results and might sometimes be seen as placeholders for academic studies.

Now, one might expect that there exists something like an all-encompassing logic of substance histories. In fact, such structures are discussed from time to time, if, for example, in a newer publication on asbestos a seven-phase model is constructed, whereby after the creation phase, the stabilization and the general acceptance phase, a "sobering up phase, the phase of substitution and the disposal phase" follows (Höper 2008: 13, my translation). Similarly, though somewhat more drastically, the American historian Robert M. Neer divides his napalm biography into the phases "hero," "soldier," "pariah" (Neer 2013: vii-viii). Now these divisions may be plausible in the case of

napalm and asbestos and perhaps also in other cases. Nevertheless, they do not permit generalization, since there are also substance histories that follow totally different phases. In the case of aspirin, for example, a reverse phase sequence can be observed, starting with distrust and finally leading to enthusiasm (Soentgen 2011/2012, 2017). More important than the setting up of generalizing rules or laws appears to be a clarification of the terminological foundation as a prerequisite for understanding these substance processes.

Substances are not only interpreted differently; they are in practice transformed and especially mobilized. They have a social life in the sense that they are sent on their way. Sometimes they even send themselves on their way when they escape control and dissipate into the air, or the water, or the ground. This mobilization, which has led to the omnipresence of synthetic substances, is the reason why laboratory histories can be expanded to global histories. Already in 1929, Ernst Jünger in an essay on World War I spoke of the "total mobilization" ("*Totale Mobilmachung*") and generalized this notion beyond its military meaning saying "this, our life itself, in its full unchaining and in its merciless discipline, with its smoking and glowing realms, with the physics and metaphysics of its traffic, its motors, airplanes and cities of millions to look at, in order to foresee with a feeling of dismay mixed with lust, that there is no atom that is not at work" (Jünger 1960: 132, my translation; cf. also Riis 2001: 100). This "total mobilization of the being" refers not only to the monstrous amount of synthetic substances brought into circulation, one can also think of the rising number of elements that we bring into service and mobilize. Elements that were only a term for chemists a few decades ago are topics of political debate nowadays (cf. Zepf 2014: 6 and 20). Suddenly they have a "social life." What is happening here?

The most important and most common form in which a substance characterized or produced in a laboratory or factory gains an extended social life is that it becomes a commodity or an exchange object. Not primarily for one's own use, but above all for exchange, substances are isolated, transformed, and mobilized. When substances are marketed, industrially produced and sold, they surface in the everyday life of many people, directly as substances or incorporated in things for use, but also as waste.

Exchange is an elementary social act that can be performed even if the partners are totally strange to one another (Kondylis 1999: 514). Silent trading, in which one side lays down the objects selected for barter at a specific place, then withdraws and thereby gives the other side opportunity to approach and to carry out the exchange, is also possible by groups antagonistic to each other (ibid.). In modern society, the importance of exchange has grown further and further: "Mass production and mass consumption have enormously increased the density of networks of exchange" (ibid.: 520, my translation). Modern science is dependent on this network of exchange,

as Marx and Engels already emphasized: "where would science be without industry and trade? Even this 'pure' science indeed receives its purpose as well as its material only through trade and industry" (Marx/Engels 1969: 44, my translation). Science transforms these networks of exchange, finds new ways through invention so that desired substances, coveted trade goods, could henceforth be produced from comparatively worthless things. Thus colorfast dyes could be produced from anthracite coal tar, camphor from pine tree resin, and saltpeter from the air.

For substance histories, the much-cited approach of Arjun Appadurai in the context of the "material culture studies" (cf. Hahn 2005) is an important theoretical point of reference up to now. In his famous introductory essay of the seminal volume "The Social Life of Things," he developed an analytic raster for the investigation of "commodity paths" that has inspired many substance studies.[3] Appadurai places the "commodification" as the central point, reaching back to classical texts on political economics, especially from Marx, but also from Simmel and Sombart.

"COMMODITY PATH" AND "DIVERSION": THE STARTING POINT OF ARJUN APPADURAI

First of all, I would like to summarize the argument of Appadurai's text, a critique then follows. I refer in the following to the edition of the text that Appadurai published in 2013.

According to Appadurai, things are in motion because they are traded. An autonomous self-movement of substances or things (leaking of oil, etc.) is not taken into account (cf. Soentgen 2014). The exchange can proceed in different ways, as a gift or as merchandise. It is made clear that those "substance flows," that in many presentations are almost naturalized and that usually run from South to North[4] are always socially arranged.

Appadurai refers to Marx. Commodities are, for Marx, objects that are not only meant for immediate use, but are intended to be traded. Appadurai shares this interpretation: "Let us start with the idea that a commodity is anything intended for exchange" (Appadurai 2013: 15). What can be traded in a society is subject to underlying societal "regimes of value" (ibid.). In different societies different objects can be traded that elsewhere are not even considered as goods, for example, people. Although Appadurai agrees with Marx's diagnosis that "modern industrial capitalism [. . .] [is] the most intensely commoditized type of society" (ibid.: 21), he argues: "the comparison of societies would be a most complex affair in regard to the degree of 'commoditization'" (ibid.: 13–14). For Appadurai, whether a concrete object can really be traded transculturally as a piece of merchandise depends on the

cultural and political framework. Especially the emphasis on the societal way that the commodities are construed continues a Marxist motif, but expands it, however, by referring not only to economic and technical but also cultural and political conditions. This is important because in capitalistic societies, in fact, global supply chains can be set in motion. On the other hand cultural and political conflicts could ensure that specific substances, certain drugs for example, will be taken out of trade circulation as "not tradable" (Soentgen 2011/12, 2017). Such substances then are, at least officially, no longer trade commodities. They certainly can continue to be traded on the black market, whereby they are transformed in many respects.

Appadurai states: "The diversion of commodities from specified paths is always a sign of creativity or crisis, whether aesthetic or economic" (Appadurai 2013: 32). Often it is the demand side, as he later determines, by which new paths arise (ibid. 35). Appadurai thereby endorses Baudrillard's criticism of the Marxist political economy and shares his diagnosis that needs could in no way be conceived of as naturally given constants, but rather are subject to social and political construction. He emphasizes that consumption is always politically loaded: "I suggest, that consumption is eminently social, relational, and active rather than private, atomic, or passive. [. . .] [O]n the one hand, demand is determined by social and economic forces; on the other hand, it can manipulate, within limits, these social and economic forces" (ibid.: 37). In line with Walter Sombart, Appadurai illustrates this hypothesis with examples from the history of luxury goods. Summarizing, he writes: "Demand is thus neither a mechanical response to a structure and level of production nor a bottomless natural appetite. It is a complex social mechanism that mediates between short- and long-term patterns of commodity circulation. Short-term strategies of diversion [. . .] might entail small shifts in demand that can gradually transform commodity flows in the long run" (ibid.: 44). What Appadurai refers to here is the inner instability of commodity paths. Already the Marxist theory refers to the internal contradiction in the trade of merchandise that lies in the fact that what matters above all to the producer is the exchange value, to the buyer the use value (Haug 1972: 14–16).

With reference to the relationship of power and goods circulation Appadurai convincingly concludes:

> In a surprisingly wide range of societies, it is possible to witness the following common paradox. It is in the interest of those in power to completely freeze the flow of commodities by creating a closed universe of commodities and a rigid set of regulations affecting how they are to move. Yet the very nature of contests between those in power (or those who aspire to greater power) tends to invite a loosening of these rules and an expansion of the pool of commodities. (Appadurai 2013: 60)

A prerequisite for the establishment and longer-term maintenance of new "diversions," according to Appadurai, are values, since goods produced on diverging paths must, after all, be sought after and therefore valued. This evaluation is politically determined: "Focusing on the things that are exchanged, rather than simply on the forms or functions of exchange, makes it possible to argue that what creates the link between exchange and value is politics, construed broadly" (ibid.: 9). An example may be the swadeshi movement in India—locally produced textiles that were produced and worn as an act of resistance to British colonialism.

CRITIQUE OF THE APPROACH OF APPADURAI

My critique of Appadurai's approach, howsoever groundbreaking his essay may be, concerns the outdated notion of materiality that is presupposed in his materialistic theory. What a "thing" (or a substance) really is, whose "social life" should be elucidated, is not considered by him but taken for granted.

In spite of the inclusion of political factors, the picture that Appadurai draws of trade routes and their "diversions" is, for the most part, linear, clear, and logical. The commodities themselves are passive, they are merely moved. Only people are active as producers, traders, and consumers, the things and the substances, however, are passive in every aspect. It is an almost Cartesian notion of materiality that Appadurai presupposes uncritically. Self-activity of substances is not taken into account. Therefore, social conflicts along the commodity paths in the Appaduraien framework can only be thought of as conflicts among the different parties who are actively involved in the production or trade or consumption of specific products. Those who are at a disadvantage through a certain novel method of production may enter into conflict with those who profit from a new commodity path (such as the beet sugar producers with the saccharin manufacturers about 100 years ago, cf. Merki 1993). But many modern conflicts over substances have totally different themes. The modern commodity paths are not linear, but rather show a rhizomatic structure.

I would like to explain *two aspects* that are connected with the nature of substances themselves and thus have special relevance for modern commodity paths and hence substance histories: side effects and dissipation. Both share the characteristic that the substances themselves are considered as active and develop unanticipated effects.

Side Effects

The term 'side effects' originally stems from pharmaceutics. It was coined by the Berlin pharmacologist and toxicologist, Louis Lewin, who first defined

the term and elaborated it thoroughly in numerous examples in his book *The Side Effects of Medicines* (Lewin[2] 1899: 3, first published in 1881). The book is a milestone of substance theory, because the undesired side effects of many substances were brought to light for the first time, though in a limited context. The term "side effects" that Lewin introduced can be expanded beyond the strictly pharmaceutical side effects to ecological, social, and cultural-economic side effects. In this expanded sense the philosopher Eduard Spranger speaks of the "law" or at least the "principle" of undesired side effects, which he wants to be known and understood as "uncertainty relation" (Spranger 1962: 14–15), because "always, and necessarily an incongruent relationship enters between a clear bounded desire and its real result" (ibid.); Spranger's definition supplements Lewin's term.[5]

Ecological side effects illustrate the expanded term "side effects" in an important way; Spranger himself already addressed such side effects. They are, as the histories of Contergan, Asbestos, DDT, or CFC (and many others) show, often unexpected and negative to certain groups of people. Thus, they lead to social conflicts and expand the social life of substances.

Dissipation

Dissipation characterizes the tendency of substances to escape control and go their *own* way (cf. Soentgen 2014). Substances are never passive, but rather show very specific tendencies and affinities; for example, certain substances may rust quickly, can char, become hard, brittle, explosive and so on. All substances have in addition a certain inner tendency, namely that of scattering themselves over the Earth, distributing themselves in space according to their own dynamics, to dissipate. Sweaters give off fluff, textiles create dust, carbon dioxide and spray can gases distribute themselves in the atmosphere, chemicals (for example, hormones) reach streams and rivers with effluent water, oil spreads itself, and so on. This self-spreading of things can be reversed to a limited extent through collecting, but such collecting will never establish the status quo ante, since dissipation is an infinitive fine-graded process.

The specific self-activity I call the *tendencies* (*Neigung*) of substances—in contrast to their suitability (*Eignung*) (cf. Soentgen 2008). Such tendencies are characteristics of the substance itself. The tendencies of substances were known to alchemical theory since antiquity; they were, in the course of time, systematized with the terms "affinity," "elective attraction," and so on.[6] Tendencies are, and this is what relates to us, specific for this or that substance, even if they are dependent on different boundary conditions, for example, temperature. The term tendency is connected with the inner plurality of the material object, for individual substances are characterized especially

through their specific tendencies. One tendency seems to be universal, so that it is scarcely noticed at first; it is the (already mentioned) tendency of substances to distribute themselves over the world. Once released, they cannot be brought back completely. This is the dustpan-paradox: It is impossible to re-collect all the dirt that is on the floor with a dustpan. When one sweeps it up, a line of dirt still remains, also, when one turns the dustpan and sweeps it from a new direction toward one's body it becomes thinner and shorter, but doesn't disappear.

Matter is scattered, like energy is, according to the second law of thermodynamics. In all natural processes, energy is conserved, but it will be scattered and therefore devalued for practical uses. What is the case for energy, one can transfer to substances as a result of the physical law of the equivalence of mass and energy. Also substances scatter themselves spontaneously. They mix spontaneously with other substances, evaporate, or crumble away.[7] More technically and more precisely this process is described in chemical thermodynamics through the term of chemical potential of portions of substances. The tendencies to specific transformations can be represented through the chemical potential (μ)[8] which in its turn is closely associated with entropy.

The tendencies of substances at first attract little attention in our modern world because we are surrounded by substances at a standstill, whose self-dynamic, apparently, is for the most part suppressed, so that their planned, linear functions remain valid for as long as possible. We use tools out of non-rusting steel, the paper of our books is of an archival quality, our apartment textiles contain fire-retardant materials, our glass is (relatively) crack-resistant, thermally resistant, and chemically inert; we consume ultra-filtered fruit juice and centrifuged and ultra-high temperature heated milk. On the other hand, an often unnoticed dissipation accompanying and joining production and consumption can be found: asbestos fibers loosen themselves from things and get into the air; formaldehyde vapors diffuse out of pressed wood sheets; softeners in plastic emit vapors. Each use of a material thing is a (minimal) usage by which the thing becomes less. At the end of its use the dissipation often increases exponentially as refuse, ash, fine dust, and carbon dioxide; things distribute themselves and their remains in the soil, air, and water.

This self-distribution of substances and things has, in the meantime, taken on a global dimension, as manifested in the ozone hole caused by propellant gases, the rise of the carbon dioxide concentration in the air, the eutrophication of waters through artificial fertilizers, or (earlier) laundry compounds, or plastic garbage in the ocean. If substances are given the opportunity through human action to distribute themselves in the environment, I would like to talk of mobilization. The mobilization of things and substances, that is, of material objects, is a part of the often noted mobilization of people, images, organisms (neophytes and neozoons), and streams of commodities.[9] It must

increase with economic growth, as far as this persists in the increase of production of material goods. It is the symbol of the typical environmental scandal, such as occurred in Seveso or also in Basel and many other places. Through an accident, for example a crack in the tank, substances leak out and distribute themselves as a poisonous cloud.

On the one hand, a substance can be artificially manufactured, distributed deliberately in nature, and then left to its fate, so that it is distributed in the soil, in drinking water, or in the air. An important example is the artificially manufactured nitrogen fertilizer (cf Ertl, Soentgen 2015). On September 9, 1913, the Haber-Bosch process was first put in operation in Oppau, Germany. At first, it synthesized only ten tons of ammonia per day that were planned for nitrogen fertilizer.[10] In the year 2011, 136 million tons of reactive nitrogen in the form of ammonia were synthesized worldwide.[11] This is about the same amount of nitrogen bound on land through biological processes (Smil 2001: 178).

Only 4 to 14 percent of the reactive nitrogen produced for artificial fertilizer is actually converted to food and thus reaches its intended aim (cf. Galloway/Cowling 2002: 66). The greatest part, about 90 percent, evaporates and seeps on the long path of this commodity from the chemical plant to the fields, and into our breakfast cereal. It distributes itself in the water, in the air, in the earth, and reacts there on its own in the food chain. In the Gulf of Mexico, every year in spring a dead zone spreads out in the ocean—a completely lifeless zone, without crabs, without shrimp, without fish. This is an effect of the nitrogen load of the Mississippi that flows through all the great corn states and thereby accumulates nitrated ground water from the fields (cf. Gorman 2013). Alongside the enormous increase of biological production that this invention enables in agriculture, there is elsewhere, because of the dissipation, a total loss of biological production. The damage that arises to the fisheries and tourism of the states bordering on the Gulf of Mexico reaches into the billions. For the European Union, a recently published calculation estimated costs between 70 and 320 billion Euros arising every year from nitrogen pollution. This is many times the value that nitrogen fertilizer use brings for agriculture (Sutton et al. 2011: 159).

By this type of mobilization substances are to a certain extent physically dissipated, dissolved, and spread out. The process can, however, even be more complicated when organisms come into play. Thus, a bioaccumulation, a gradual enrichment of an originally very low and therefore harmless concentration of a certain substance can occur along food chains. James Lovelock has very clearly described this process in the example of DDT: "Small insects that had accumulated enough insecticide to disable, but not kill them, were an easy target for predators that might be larger insects, or small mammals like voles. These in turn would be prey for larger animals, and for birds like owls or hawks. Pesticides like DDT are only slowly metabolized

and gradually accumulate in the animal's fat; because of this accumulation the pesticide concentration in the tissues increases at each step up the food chain. The owl that eats the vole therefore takes in a much larger proportion of the pesticide than did the insect at the start of the chain. The concentration of pesticides in the owl could soon exceed toxic levels, and the owl's progeny would be born poisoned" (Lovelock 2014: 126).

Finally there is another dissipative process at the margin of commodity paths, which we may call co-mobilization. A substance is hereby mobilized when another substance is activated. An example is arsenic, a relatively common substance that was only locally threatening for few people in earlier times. Because arsenic, however, frequently occurs in association with "noble" metals—especially with gold, indeed even is referred to as a *pathfinder element* leading directly to it—it will be mobilized when there is mining for gold.[12] The neighbors of goldmines therefore very often have to fight with increased arsenic concentrations in the soil and water. It is estimated that about 100,000,000 people ingest arsenic-contaminated water.[13] If mining activity is expanded or intensified (but also if arsenic-containing pesticides or wood preservatives are brought out and electronic scrap containing arsenic gets into the environment), this number will grow.

Dissipation is not merely an abstract process by which a specific quantity of matter is distributed along commodity paths that thereby would be made economically unusable. Substances react in appropriate surroundings, they have physical, chemical, physiological, and ecological effects and just this makes the dissipation so problematic, just this makes them a topic of political and societal discussion and conflict. Thus, as modern chemistry has undertaken the attempt to "tame" the substances and thereby has also wrested significant successes, so the dissipation shows the corresponding loss of control.

DISSIPATION AND SIDE EFFECTS CREATE NEW TYPES OF "SOCIAL LIFE OF A SUBSTANCE"

Substances seep, evaporate; they are not only moved passively in the course of production, commerce, and employment, but also move themselves, mostly in connection with their intended use according to their own principles and thereby cause, under certain circumstances, ecological and/or social problems that can lead to new types of social conflicts.[14] It is these conflicts, as a result of dissipation and side effects, that in newer substance histories—be they concerned with Thalidomide, Agent Orange, or nitrogen—are placed at center stage.

There arise thereby complex, split-up stories, as the American historian William Cronon has formulated: "In the beginning was the story. Or rather:

many stories, of many places, in many voices, pointing toward many ends" (Cronon 1992: 1347). Edwin Martini sounds very similar when he announces his history of the defoliant Agent Orange:

> I have treated Agent Orange very much like a mystery or a puzzle to be solved. My approach to the topic is driven not by a political agenda but by an interest in following the trails of evidence in a variety of places and in reconstructing the history of this controversial substance by placing that evidence in a broader context. By tracing these stories across temporal and geographic boundaries I have sought at the most basic level to understand how actors and communities around the world shaped and were shaped by Agent Orange. (Martini 2012: 4)

The plurality of the stories reflects the teleological and material scattering of substances on the one hand, and the different positions of the narrator (or narrators) on the other. It shows that the usual narration of more or less linear biographies, commodity paths or "substance flows" is thoroughly questionable.

NOTES

1. The concept has been in use for a long time in different research contexts, which I will address in the following. In the Environment Science Center of the University of Augsburg it was originally introduced in the framework of university teachings (Huppenbauer und Reller 1996), later further developed terminologically (Böschen et al. 2004), in exhibitions (Staub 2005, CO_2 2007, Nitrogen 2013), a book series (Stoffgeschichten, Oekom Verlag, München since 2004), and tested in the university teachings as well as transferred into school contexts (Schmidt/Steber/Soentgen/Reller 2007).
2. This slogan stems from George Marcus (1995: 106f.).
3. See only those in the anthology of Topik et al. 2006.
4. Here critically Espahangizi 2014 : 204.
5. Spranger adopts Wundt's doctrine of the heterogeneousness of purpose. See Wundt 1903: 52; for Wundts doctrine see, among others, Lübbe 1978, Bloch 1967, Graumann 1996.
6. The best overview is found in Adler 1987: 37–72; see also Berger 2000: 8–45.
7. Nicholas Georgescu-Roegen as a result of these consideration even proposes a Fourth Law of Thermodynamics: "Dans tout système clos, la matière utilisable se dégrade irrévocablement en matière non-utilisable." (In all closed systems, usable material irrevocably degrades into non-usable material"). Georgescu-Roegen 2008: 203f. Since Georgescu-Roegen argues on the basis of physical thermodynamics, the process of dissipation appears to him as a neutral "self-distribution" of matter. There are, however, substances with specific tendencies that distribute themselves; it is this that gives the process its problematic nature.

8. Wiberg 1972: 161–168; Job/ Rüffler 2011: 85–118.
9. Thus Appadurai 1996: 37; see also Keller 2009.
10. Timm 1963: 818.
11. Commodity Research Bureau 2012: 95.
12. Kevin R. Henke and David A. Atwood, "Arsenic in Human History and Modern Societies,"*in Arsenic. Environmental Chemistry, Health Threats and Waste Treatment*, ed. Kevin R. Henke. (Chichester: Wiley, 2009), 277–302 (p. 289f.)
13. Kevin R. Henke, "Preface," in *Arsenic. Environmental Chemistry, Health Threats and Waste Treatment*, ed. Kevin R. Henke. (Chichester: Wiley, 2009), XVII.
14. Armin Reller has pointed out in numerous impressive studies the dissipation processes that accompany the use of advanced technology. See also Reller et al. 2009 on mobile telephones.

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