The relevance of soils within the concept of the Astysphere

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Abstract
No geological exogenic force has altered the earth’s surface during the last centuries in such an extent as human activity. Urban systems become main regulators for fluxes of many chemical elements on a global scale due to ongoing industrial and economic development and population increase. Additionally, urban systems are constantly expanding. For natural history, urbanisation is a new phenomenon never existed in previous geological eras. Because of the tremendous global impact of urban systems, a new geoscientific sphere is developing: the Astysphere (Norra 2009). This sphere comprises the parts of the earth influenced by urban systems. Geoscientifically, urban areas correspond to sediment formations. Within the Astysphere, soils are important as sinks and sources for pollutants and various materials, as foundation for construction activities, for water storage and local urban climate and as living space for numerous organisms. Urban soils are globally linked by substance fluxes between urban systems. Since construction materials, living conditions, traffic and industrial processes become fairly similar in the world wide urban systems, also urban soils increasingly become similar on a global scale, a process called convergence in ecology. The concept of the Astysphere grasps urban soils as entity of the globally interlinked urban systems.

Key Words
Soil, Astysphere, urban systems, Technosol, soil pollution.

Introduction
Unquestionably, volcanoes, earth quakes, wind, rain, plant and animal life enormously contribute to form the earth's face by abrupt impacts or permanent ongoing processes of lower intensity. But are they the main forces forming the present earth's face? During the last centuries no geological exogenic forces have changed the earth's surface as mankind has done. Humans have altered the morphology and element balances of the earth by establishing agrosystems first and urban systems later. Currently, urban systems happen to become the main regulators for fluxes of many elements on a global scale due to ongoing industrial and economic development and a growing number of inhabitants. Additionally, urban systems are constantly expanding and cover more and more former natural and agricultural areas. For nature, urban systems are new phenomena, which never existed in previous geological eras. The spread of urban systems over the globe is highlighted in Figure 1.

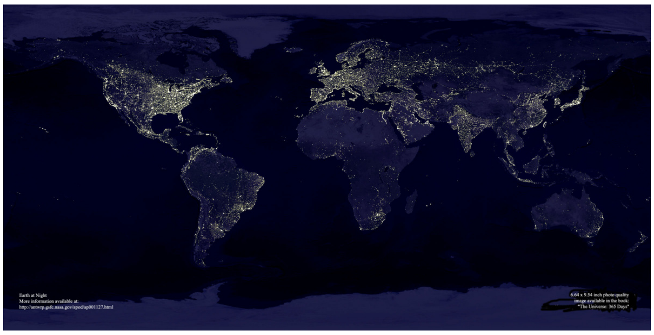

Figure 1. The lights indicated urban settlements.

For 2008 it was estimated that about 50% of the world population live in urban areas. It is estimated that in 2050 around 70% of the world population will live in urban areas (United Nations 2008). That means, till 2050 the number of urban population doubles and equates to the today’s world population. Concurrently, the urban area is constantly growing. The global extension of urban areas is under discussion. In 2000, 0.3% of the total land area of countries was urbanized. It is expected that cities grow 2.5 times in area by 2030 or will cover 1.1% of the total countries area (Angel *et al.* 2005). Other calculations from Salvatore *et al*. (2005) claim that already in 2000 up to 2.7% of the total land area was urbanized. The portion of areas developed for traffic and settlement purposes is higher in developed countries. In Germany, already 12.5% of the total area is used for traffic and settlements and every day more than 120 ha are added. Furthermore, ongoing urbanization causes the sprawl of more or less dense urban systems over the globe.

Urban systems are globally cross linked to each other by fluxes of energy, information and matter. Urban processes do not only affect urban systems within their specific borders but also remote areas by pollution via the air path or by mining activities and even tourists. Thus, a new sphere develops that changes the world's shape, the Astysphere. This Astysphere is a new approach to integrate urban systems into the geoscientific concept of spheres and an initial point for the understanding of urbanization of the earth as natural process (Norra 2009).

Walter Suess presented 1875 the concept of geoscientific spheres. He distinguished spheres, such as the lithosphere and the atmosphere to promote a comprehensive understanding of the system earth. Since then, based on the works of geochemists like Clark, Goldschmidt and Vernadsky, this idea became a dominating concept for the understanding of the distribution of chemical elements in the system earth. Later, due to the importance of human beings on global element fluxes, the terms technosphere and anthroposphere (Bacchini and Brunner 1991) were introduced. Nevertheless, in face of the ongoing urbanization of the earth, this concept is not any more precise enough to develop a comprehensive understanding of global element fluxes. Thus, it seems appropriate to classify the anthroposphere into an agriculturally and an urban dominated sphere. According to the greek terms agros (αγροζ) for agriculture and asty (αστυ) for city or town in opposite to the surrounding farmland, the anthroposphere comprises an agrosphere (Krishna 2003) and an astysphere. The agrosphere corresponds to the rural and agrarian environment, and the astysphere represents the urban environment. Both spheres are intensively connected due to former and recent agricultural activities on urban land and vice versa. Figure 2 displays the position of the astysphere within the earth's spherical system in a simplified sketch. The Astysphere comprises also parts of other spheres such as the atmosphere, hydrosphere and the pedosphere and is always part of the biosphere. Within the Astysphere, soils are important sinks for elements and materials and show specific development properties.

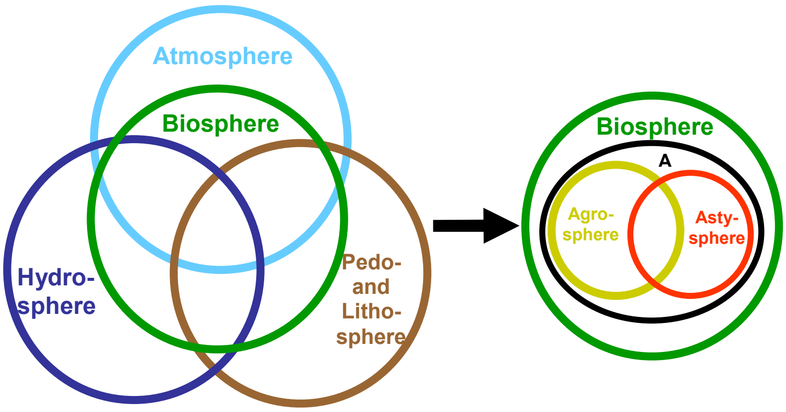

Figure 2. The position of the astysphere within the earth's spherical system. A.: Anthroposphere

Methods

Urban soil investigations can be classified into two different types. One is focused on soil properties of specific soil profiles to investigate the soil development or contamination at specific locations. Soil pits are dug out and soil horizons are differentiated and analyzed. Those soil profiles can be classified according to soil classification systems such as the WRB or of Germany (AK Stadtböden der Deutschen Bodenkundlichen Gesellschaft 1997). The soil profiles can be connected to specific urban land use types and urban soil maps can be generated. The other type of urban soil investigations considers the urban wide pollution of soils by specific land uses that happen for a large part via the atmospheric pathway. Maps of urban soil pollution are produced by interpolation routines. Both methods highlight the global connection of urban soils as part of the Astysphere.

Results and discussion

Figure 3 shows an example of a soil profile in Qingdao, China, investigated in 2004. This figure highlights the sedimentation of anthropogenic materials in urban systems. Urban soils can contain slags, ashes, waste, building rubble, tar, sludge, etc. and mixtures of those materials. Furthermore, these artificial materials can be mixed with natural substances. This process of waste and material disposal in urban systems corresponds to the geological process of sedimentation (Taylor 2007).

Figure 3. Technosol over capped Cambisol in the Old City of Qingdao. 87 cm of new material accumulated since the first construction development (indicated by the white band that is a lime terrace) took place during the German occupation about 100 years ago.

A comprehensive set of urban soil profile investigations were compiled by Lehmann and Stahr (2007). Typical soil profiles can serve as standard soils for specific urban land use types. In that manner, urban soil maps can be generated as presented by Grenzius and Blume (1983) for Berlin or by Holland (1996) for Stuttgart. Those maps especially consider subsurface processes and the fact that urban soils are part of the more or less human controlled urban development process. With respect to the urban wide pollution of soils by specific land uses that happens for a large part via the atmospheric pathway maps of urban soil pollution were produced by interpolation routines. They show the urban footprint of the urban wide pollution as is demonstrated for Karlsruhe (Figure 4). Similar investigation have been carried out in various cities all over the world, e.g.: Rhichmond Upon Thames, UK: Kelly *et al*. 1996; Osnabrück, Germany: Bloemen *et al*. 1998; Tallinn, Estland: Bityukova *et al*. 2000, Palermo, Italy: Manta *et al*. 2002; Sevilla, Spain: Madrid *et al*. 2004, Shenyang, China: Wang *et al*. 2006, Damascus, Syria: Möller *et al*. 2005 and Glebe, Australia: Markus and McBratney 1996. By these studies, it becomes obvious that the process of soil pollution by and in urban systems is a globally occurring and systematic process. The global urbanization process makes sure that more and more soil is affected and converted to urban soil.

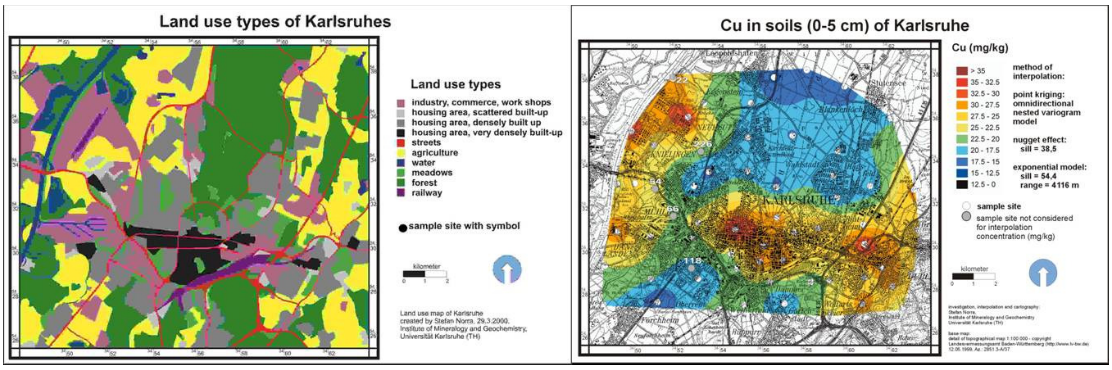

Figure 4. Distribution of land use types and Cu concentration in the upper 5 cm of soils of Karlsruhe, Germany. Highest Cu concentrations match primarily to industrial and inner urban areas. (Norra 2001)

The pedosphere within the astysphere

The pedosphere is one of the main compartments of the astysphere. Here, in urban soils, anthropogenically steered sedimentation processes occur. Urban soils act as sinks for technological materials and anthropogenic emitted pollutants all over the world. Since materials, which are deposited in urban systems are fairly similar in different parts of the world (construction materials, organic waste, household waste, industrial waste such as slags and sludges, technological products such as glass and plastics, etc.) the urbanization process compensates natural differences of soils caused by climate or parent rock. Such a process is called convergence in ecology.

One typical process all over the world is e.g. the input of alkaline materials (lime, mortar, concrete) generally resulting in neutral to basic urban soil reactions. Further processes are the input of heavy metals via the atmospheric path way. Therefore, globally, urban soils contain higher concentrations of those elements as do unaffected soils. Furthermore, those elements occur in ratios not abundant in non-urban soils. Due to worldwide transport activities between urban systems, urban soils contain information from distant other urban and non-urban systems. Those information is contained in materials that could be residues of Brazilian or Australian coal in German soils, African banana peel in European road side soils, abrasion particles from trolley systems of South American copper, packaging material wastes from all over the world, wood, paper, steel, alloys, etc.. However, until now, far too little emphasis has put on fundamental research of urban soils that mainly occur in newspapers and in research projects in cases of highly toxic but locally limited cases of soil contamination. Soil development processes in urban systems are far too little understood as well as their sink properties. Similarities and differences between urban soils from different regions should be investigated with more effort, since although the materials deposited in urban areas are often comparable, but development processes urban soils undergo might be different in varying climates. Form the viewpoint of the concept of the Astysphere, the extension of urban soils will increase in future. Those soils will be affected by pollution and deposition of various materials with rates not comprehensively known yet. However, recent urban soils will form a globally distributed rock unit of varying extension in geological future.

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