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# Developments in urban environmental information perception and communication

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**Abstract:** Urban environmental information (EI) is related to knowledge concerning the status, the pressures and the consequences of environmental quality parameters to human life and the urban surroundings. One of the most important aspects in the life cycle of EI is knowledge generation and flow, data management and information dissemination between ICT systems and environmental actors, players, or interested parties. In the present paper, urban air quality serves as the application domain, for which the following issues are discussed,

- Analysis of the way that environmental information is related to urban structures (roads, buildings, etc)
- Investigation of the spatial and temporal urban dimensions of the perception and interpretation of environmental pressures from the citizens' point of view.
- Suggested presentation and communicating methods of environmental information to optimise its use and effectiveness towards quality of life

The discussion is initiated from the concept of Ontologies, and provides a perspective on urban environmental information perception and communication for air pollution. The insights reported may be used as a basis for the design of information/management systems.

***Keywords**:* Ontologies, communication, perception, quality of life, environmental information.

## 1. INTRODUCTION

One of the most cited definitions of ontologies states that *'An ontology is an explicit specification of a conceptualization'* [Gruber, 1993]. Another well known definition is that of Studer et. al., 1998, according to which: *'An ontology is a formal and explicit specification of a shared conceptualization'*. By "projecting" these definitions towards contemporary life in urban agglomerations, one could state that an ontology is a formal, explicit, and equally communicative concerning its content, specification of a conceptualisation, and as such it may be applied to urban life and activities. The latter makes use of the human centric principle concerning the relationship of the being with the world surrounding it, as stated in Plato's *Kritias* in the section on the *cave metaphor*. Thus, the main goal of an ontology may be considered *to effectively structure the representation and communication of information and concepts in an explicit way*. This aspect is of importance when it comes to the interactions that the human being experiences with its urban environment, especially taking into account that more than 60% of the European population lives within cities: there is a dense network of interactions between the individual and urban facilities and services, like transportation, energy, telecommunications, social and financial services. Citizens make use of such services in order to fulfil their needs and by doing so they generate a clear impact on the sustainability of the environment they live in. The introduction of ICT has resulted in the enrichment of available (to citizens) physical facilities and services with digital ones, thus creating the

concept of digital urban infra-structures, existing in "parallel" with the physical ones; Digital services for citizens are represented by local (city-based) content such as community events, nightlife, localized yellow pages, entertainment, visitor's guide, and e-commerce [ISP Glossary, 2008], and are provided via Internet-based information portals, personalized WAP, SMS and voice services, and electronic information boards. As these services are developing more and more in parallel with developments in ICT, they may support new (advanced) ways of managing quality of life on a personal level, with the aid of information related to the quality of the urban environment. The present paper addresses these issues for the environmental domain of air quality, as the latter represents one of the most profound, well recognised and widespread environmental pressures of contemporary Europe.

## 2. URBAN AIR QUALITY

As already proposed by Dewdney, 1998 "the urban surface is a continuous screen, or a series of overlapping screens, onto which representations are projected." Karatzas, 2003 and 2007, already suggested that urban air quality management and information systems may support decision makers towards environmental management for a sustainable society, and may also "trigger" the creation of new, user-friendly, human-centric environmental information services that advance the improvement of the general quality of life in the city. These services, when applied on an operational basis, can help in the "formulation" of a new, citizen level perception on the environmental semantics of their urban environment and on the influence of their behaviour to the sustainability of their everyday living: Perceived residential quality was found to depend on physical neighbourhood attributes, such as noise and air pollution, on psycho-social characteristics, like safety or crowding, and on the availability and quality of neighbourhood facilities [Van Poll, 1997]. The introduction of human-centric, environmental information services is thus expected to add a positive semantic (in equivalence to physical) attribute to the urban environment, as it will increase the people's feeling for access to services, facilities and amenities, that plays an important role in the perception of quality of life [Sénécal, 2002]. Air quality may play a leading role in becoming the pilot for flexible, adaptable, quality of life electronic information services, incorporating the recent advances in the research results of atmospheric sciences and health-risk assessment, the forthcoming developments of spatial services included in the INSPIRE directive (http://inspire.jrc.it/), and the mandates of EU for e-government and e-participation.

## 3. PEOPLE'S PERCEPTION AND AWARENESS OF AQ

Environmental awareness is being addressed with an increasing intensity in recent years. Thus, as an example, the German Federal Ministry for Environment, Nature Conservation, and Nuclear Safety and the German Federal Environmental Agency are investigating the environmental awareness and behaviour of German citizens, issuing study results every 2 years [Umweltstudie, 2006].Yet, studies focusing on AQ are not so common and systematic, but they have provided sufficient evidence for drawing a basic sketch concerning what people believe/have in mind about air pollution and related notions. Thus, according to Bickerstaff and Walker, 2003, studies of human response to air pollution first emerged in the 1950s in the USA, where social survey techniques were used. Environmental concerns were expressed for a national level, yet people failed to realise that pollution may be a serious threat to their local community [Murch, 1971]. Public opinion surveys were carried out by the State of California Department of Public Health in the late 1950s and measured psychological dimensions of air pollution. In the UK, early work on the perception of air pollution focused on the operation of Smoke Control Areas under the Clean Air Act of 1956.

In a paper of Skamp et al [2004] on student's ideas and attitudes about air pollution, the authors provide a review of similar work and present their own research results for Australia, for students from ages 6-20 years old. It is interesting to note that according to this study, the majority of students believe that air pollution is natural, and is attributed to animals. The majority of students identified the negative effects of air pollution for the environment and human health, asthma being the disease directly associated with the

problem. Another interesting finding was related to what could be done for improving air pollution, where the majority of students required more education and suggested personal action (environmental friendly behaviour). Thus, the issue of providing AQ information designed to trigger environmentally friendly behaviour, while educating the recipient on the subject, is emerging as important.

In another study, Elliott et. al., 1999, reported that an important parameter on human perception of air pollution is the role of sensate factors as primary predictors of concern, i.e., experience with black soot, bother by air-pollution-related odours, and reported impacts on health and daily life, bringing to the surface the issue of personal experience. Nevertheless, according to Bickerstaff and Walker, 2003 (and references therein), recent qualitative studies show a very low level of awareness and use of air quality information services - in particular those provided by central government. These studies have also revealed a consistent, if muted, scepticism of the motivations of government (or industry) in interpreting and presenting air quality data. When it comes to the relationship between information provided and public understanding, it is mentioned that "…the net result is that the information provided bears little relationship to most people's encounters with, or cultural understanding of, air pollution, and in consequence is either dismissed as an irrelevance or at worst taken as (further) evidence of disingenuous government motivations in the provision of information. The failure of recent changes in the format of air quality information …. to resolve these barriers to use, provides strong evidence of more deep-rooted problems in the communication process, relating to the construction of air pollution problems and assumptions about human behaviour embedded within scientific and policy communities".

A key issue is the understanding that the air as perceived, and actual pollution (the latter based on measurements), are not always associated, underlining an information gap (of both temporal and spatial nature), concerning air pollution levels and air quality perception. Brody et. al [2004], report that while there are research results indicating no correlation between perception and high air pollution levels, there are others demonstrating that awareness of air pollution is scientifically correlated with actual measurements, and that there is a distance decay of concern spreading outward from urban centres towards rural areas. They also report on the linkage between geographic locations and forming perceptions of air quality, yet, such perceptions are also influenced by social, cultural and behavioural parameters. The work of Brody et. al. [2004], for the Texas area also suggests that the role of media providing AQ information is of paramount importance for the way that citizens understand air quality and respond to governmental policies that seek to improve local and regional air quality conditions. As they put it ".. in this respect, more accessible and far-reaching communication channels should be established to provide the broader public with the best available information on air quality conditions". To this end, the conclusion reached by Higgs, 2005 for the dissemination of environment related information concerning siting of waste facilities may be of use: "participative approaches that use IT-based methods, based on combined geographical information systems (GIS) and multi-criteria evaluation techniques that could involve the public in the decision-making process, have the potential to build consensus and reduce disputes". Moreover, Lindley and Crabbe [2004], suggest that IT tools, especially GIS based, should be used for the spatial representation of AQ related information, while also additional visualization methods, including 3D, should be applied, thus verifying the findings reported by Karatzas et. al [2005], concerning the APNEE-TU project briefly summarised as follows|:

- Use of graphs, colours and smileys was found to communicate the content and the "threatening" level of warnings related to urban air quality episodes in various EU countries, in a much more effective way in comparison to the "traditional" usage of scientific terminology and numbers.
- Location-based services, provided with the aid of either personalised (mobile-phone based), or web based information channels, were preferred by citizens more than services that did not include any location oriented information.
- The visualisation pluralism achieved with the aid of on-line 3D animations of pollution was considered to more effectively communicate the air quality problem to citizens.

When it comes to the sociological dimension of the problem, Rydin [1998] notes that the language of air quality policy has traditionally not been placed in the context of moral responsibility to reduce harm to others, but in the context of individual responsibility for self-protection. Petts, 2005, also states that "Altruism gains importance in the context of equity arguments that those most affected by poor air quality are those least able to make a difference and the least contributors, to the problem", and poses an interesting question that we should have in mind when designing air quality information services: " Is it likely that information stressing the individual and social benefits of action will support choice and responsibility or is some further institutional insentivisation required". Petts also mentions that "numerous studies confirm that the public is worried about air pollution. Negative perceptions are shaped by proximity to industry, measurements, and personal experiences. However, there is little evidence of beliefs in strong causal links between diseases and air pollution; rather there is an understanding that chronic illnesses, such as allergies, asthma, and bronchitis, can be affected by air pollution". This finding suggests that AQ information should certainly address those suffering from respiratory diseases, yet it should also underline the consequences of long term exposure to high concentration values.

In the context of urban air pollution, it is argued that there is no benefit to the individual in taking action through the choice of a less polluting but more inconvenient form of transport, other than the potential satisfaction of altruism [Rydin, 1998]. On the other hand, local authorities may also support the opinion that from information supplied, the public can make informed decisions about their lifestyle and how they effect the environment [Jenkins, 2006].

## 4. AIR QUALITY AND URBAN STRUCTURES

From already published research results, it was evident that urban structure typology plays an important role in the development of everyday economic activities [Joosten and van Nes, 2005], while infrastructures and service availability are related to the perception of environmental quality [Majumder et. al., 2007] Thus it may be suggested that it influences the way that people perceive the quality of the environment they live in. It is therefore necessary to identify aspects of the urban typology related to such a perception. In order to do so, and as we lack field research and related results, and as the scientific literature barely exists in this field, we make use of subjective intuition and scientific judgement, a methodological basis that spans its limitations as far as the absence of actual data may allow.

One basic typology is the distinction between inside and outside spaces, the public versus the private and the physical relationship between those spaces. One of the typological elements that we identified was that of a threshold or a buffer zone (doorways, entrances, etc). This element is directly related to the way that people communicate with their environment and with each other, and its existence was identified to prepare the individual towards entering the proper communication mode and physical interaction mode. As a consequence of that, such buffer zones act as "smootheners" of environmental information towards the individual. This finding also led us to suggest that open spaces (parks, squares, open markets, etc) are actually an ensemble of communication functions that are clustered together on the basis of their resemblance and scope (marketing goods, communicating with people of similar interests, exchange of information concerning social matters, taking part in major social events, etc.). Another urban typology identified was that of transportation infrastructure. The physical proximity to such infrastructures (evaluated with the aid of visual contact or noise-air pollution sensing, should be considered to be the key element the way that people interpret the quality of the environment they live in [Elliott et. al., 1999, Petts, 2005]

We therefore seek ways in which these typological concepts may be developed towards ontologies that will help to structure the communication of environmental information more effectively.

## 5. COMMUNICATION OF AQ INFORMATION

Communication is related to: presentation; multimodality; representation. These are key parameters to consider in any communicational context. We need to consider the interplay of these factors with the intended typological framework. Here we focus on the use of mobile devices – phones, which are the ICT paradigm that provides a new communication language with and within the digital world. This emphasis has as a prerequisite that the society of users is not influenced by problems of digital divide, which is at least at a minimum in EU countries. When focusing on mobile devices, the following significant factors may be identified: (1) Geographically locatable, localised devices and services. (2) Small size; mobility. (3) Extremely wide availability and user base (ubiquity). (4) Audio interface that may be especially natural to use. (5) Restricted visual display area.

Communication using these devices can and should trade on the above factors, which have many important implications. Information needs to be packaged efficiently (5); extended explanations are to be avoided. Hence abbreviations are important, but these are also inherently ambiguous. Disambiguation can be helped by providing complementary information on additional channels, e.g. sound (4), but comes more from context and background knowledge. A major part of context may be physical location (1) – devices can refer to this directly and e.g. indicate when a change of location (2) has been detected. Indexical features of language (e.g. “here”, “this”) take advantage of such contextual cues so can be usefully exploited. Background knowledge is often derived from shared assumptions about the meanings of terms, symbols, indicators of various kinds. Shared assumptions come from (loosely speaking) a community of users with a commonality of background. This background may be shared cultural history among the users (from education, mass media, etc.), which is an increasingly reasonable assumption (3); or may be narrower shared practices that have evolved through joint activity or attention to some task, or have been acquired through explicit training.

So, one way to look at the challenge of these devices is to ask how best to exploit the features (1-4) to overcome the display problem (5). But alternatively, one can see whether the affordances of the display along with the other factors can be combined to provide an unusually fertile opportunity for developing new communicational possibilities, such as novel symbol systems.

The difference between icons and symbols can be characterised in information theoretical terms by looking at how information is distributed between the sign itself and the user’s knowledge of how the sign was used in the past [Shannon, 1948]. As a community uses signs in communication, this distribution tends to change in the direction of exploiting the increasingly shared (background) knowledge of the community about the use of the signs; and hence signs become more symbolic[cf. Garrod et al., 2007]. This process can be exploited to create new “languages” (perhaps graphical languages, animated languages, sonic languages, etc.) that offer us new opportunities to communicate effectively and with acceptance (or “buy in”) from appropriate user groups. The ways in which these languages can emerge depend in complex ways on the nature of the devices combined with the interests, abilities and perceptions of the users. A typical example of such a development is the now familiar “text language” that has emerged among the younger generation of users of SMS messaging, which is of course restricted to the only visual messaging modality available on early mobile phones.

So when it comes to air quality information, we need to define our user groups carefully, to determine communities of communicators who will form the basis for this kind of development. We then need to provide them with suitable communicational tools. Communication in this case needs to be a two-way process: it is not enough to push information out to the users, we have to facilitate their reacting to it in some way, passing it on to others, responding with their opinions, etc. These imperatives reflect the views of Brody et al [2004] and Higgs [2005], as quoted above. They are also in some respects the basis of the much-vaunted “Web 2.0” paradigm in internet terms. Similar thinking applies in the mobile context. Users need the flexibility to define their own ways of working, as they have done with SMS. Newer devices allow for languages which can be on the one hand much richer, and on the other hand potentially more specialised to particular content domains.

To see how this might interact with the notion of typology introduced above, let's consider again the transitional boundary that exists between (a) the inside (of buildings, spaces, enclosures, even cities) and (b) the outside (the environment), the private and the public. We could call this the "threshold" – an emotive idea in architecture, and perhaps elsewhere. How do people perceive environmental threshold conditions, and how do they communicate about them? What are the roles of these conditions as barriers to movement and progress, as comforting and protective shields against various kinds of threats, or simply as transitions between contrasting situations? Such questions would be highly relevant to investigating how information should be presented, and how people would decide to present it. Identifying the crossing of (something that would be perceived as) a threshold could be an appropriate trigger for delivery of information; understanding how the threshold is perceived should certainly condition the presentation. But also, an important aspect of the private/public threshold is that the private can refer to the individual (as perhaps we initially expect), but also to the group or community. In this sense, people may perceive a physically identifiable boundary as a threshold and in a related way may perceive communicating with members of a different group as crossing a threshold. Often these notions coincide, where groups (e.g. citizens of a particular district) tend to identify with a spatial area, but they may not (as e.g. the young and the middle-aged, as distinct groups, commonly inhabit the same household). And indeed, it may be that we can use these overlaps to aid communication across thresholds. In the "buffer zones", people meet and communicate differently as compared with the inside or the outside; there is a certain ambiguity about which zone they are in, and an opportunity to allow permeation between languages. We can perhaps use these zones not only to facilitate information exchange (between groups), but also to introduce or insinuate new communicational ideas, "seeding" the communities on either side to develop their own interpretations, usages and forms of language, but nonetheless to share a certain core of understanding.

## 6. THE USE OF ONTOLOGIES

It follows from the above that different groups within the wider community will develop their own conceptualisations of phenomena, based on their perceptions, which may differ markedly, and also on their inevitably divergent group communication histories. Therefore, there will be differences when it comes to considering formal characterisations of these conceptualisations, which is to say that we will need different ontologies. To some extent, ontologies can be expected to characterise groups. In the buffer zones, we will observe ontological shifts.

This should come as no surprise. Ontologies in practice are always somewhat mutable, subject to change and evolution, and bound to communicating groups that are themselves somewhat fluid [cf. Lee and McMeel, 2006]. It means that from the point of view of describing a domain such as air quality, we should not seek to find some single ontology that will do this job for all comers. Rather we must recognise that conceptualisations of air quality will differ between communities; and we (whoever we are – scientists, etc.) are just another community. It is our job to communicate with diverse groups. We need therefore to approach them through suitable buffer zones, and "seed" these with our own concepts of the material in our domain. They will then, inevitably, take off in their own directions and become to some degree incommensurable with an ontology that would have described our original view.

This does not, however, mean that ontologies are useless. We need them to import some formal structure to the communication systems that we develop, and then indeed we can use them to characterise the very shifts and changes in those systems that demand changes to our ontology. They are hence a critical tool both for research and for development. Moreover, the differences in ontologies do not necessarily result in difficulties in communication. ICT provide methods that allow for the "collaboration" between different ontologies, including ontology markup languages. Thus, the user of a quality of life information service may combine different concepts, thesauri, and metadata, by bringing together, on the fly, different ontologies, so that an information service may be personalised and materialised on demand.

## 7. CONCLUSIONS AND RECOMMENDATIONS

In the present paper the issue of environmental information perception, analysis and communication is addressed for the domain of urban air quality. The aim is to better understand how the physical interaction of people with the environment they live in is related to the way that they understand environmental pressures. This is a research work in progress, for which the following conclusions are drawn and recommendations are made:

The human perception of atmospheric quality is closely linked to the interaction of the individual with the physical space and the available interfaces between digital services and people. The communication of AQ information should take into account a number of factors that may be identified, and should also be based on a two way communication channel, that would allow people to interact and develop common perceptions and understandings on the basis of common interests. The use of multimedia communication means may enhance communication effectiveness and advance the usefulness of such quality of life information services. On this basis, the following may serve as recommendations for future research in this area.

1. Investigation of the spatial and temporal dimensions of human perception in relation to the actual situation concerning environmental pressures in urban spaces;
2. Assessment of the communication media and modes that address the spatial and temporal scale of both environmental quality and urban life (graphs, noise, use of vibrating mobile phones as alarm notifications, etc.);
3. Analysis of aspects of geometry, shape, size and the resulting concept of proximity, inclusion, exclusion concerning quality of life environmental information services;
4. Direct and intensive participatory design, with specific user groups, of mobile interfaces that combine these media and concepts flexibly for innovative communication.

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