

CLEANING THE AIR

Mitigating air pollution
through Urban Design

Marcello Felice Vietri - Graduation Project in Urbanism - TU Delft - June 2017

Turin, Italy

When thinking of air pollution, most of the people refers to Asian countries such as China or India where the air is often unbreathable. However, despite the common believes, air pollution poses the single largest environmental risk in Europe today (EEA, 2015) and, among all the countries, Italy has the highest rate of death related to air pollution. The city of Turin, as one of the four most polluted cities in Italy, has been facing high rates of air pollution concentration for several year. Despite several attempts by the municipality to improve the quality of the air, the situation has slightly changed in the past years and the urgency of the issue calls for alternative and more concrete solutions. The graduation project, by discovering and analyzing the relationship between air pollution, built environment and urban design, aims to propose a thorough interscalar

approach able to mitigate air pollution in the city of Turin. The form and the nature of the built environment are in fact critical to air pollution concentration: street orientation and width, building heights and several other urban features play a key role in air pollution dispersion. The design proposal focuses on three design interventions which are characterized by different scales of action: from the micro scale of a single public space to an entire neighborhood. Seen together, they form a comprehensive system for mitigating air pollution whose basis rely on the discipline of urban design. Overall, the graduation project substantiates the relevance of urban design when assessing air pollution in cities. It offers valuable, effective and alternative solutions able to support the already existing urban policies in the city of Turin.

Air pollution

Air is constantly moving, crossing vast areas of land and oceans it mixes itself and its original composition has been dramatically changing throughout time. Anthropological processes such as urbanization, car introduction and industrialization and natural sources as well, are the main contributors to air quality. The World Health Organization recently (2016) announced that almost 92% of the world's population lives in places where air quality levels exceed the limit values. Further more, air pollution poses the single largest environmental health risk in Europe today (EEA, 2015). In general, As the European Environmental Agency stated, air pollution is both an environmental and social problem, as it leads to a multitude of adverse effects on human health, ecosystems, built environments and climate.

IN 2015

92 %

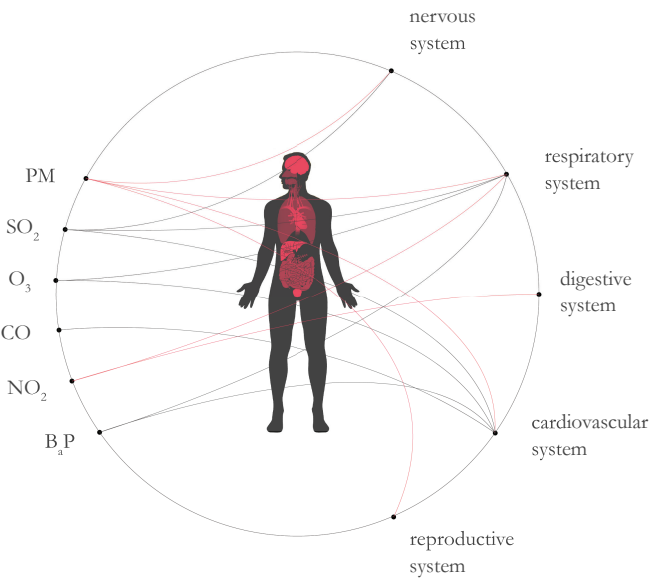
population living where
air quality levels exceed
the limit

491.000

deaths in Europe

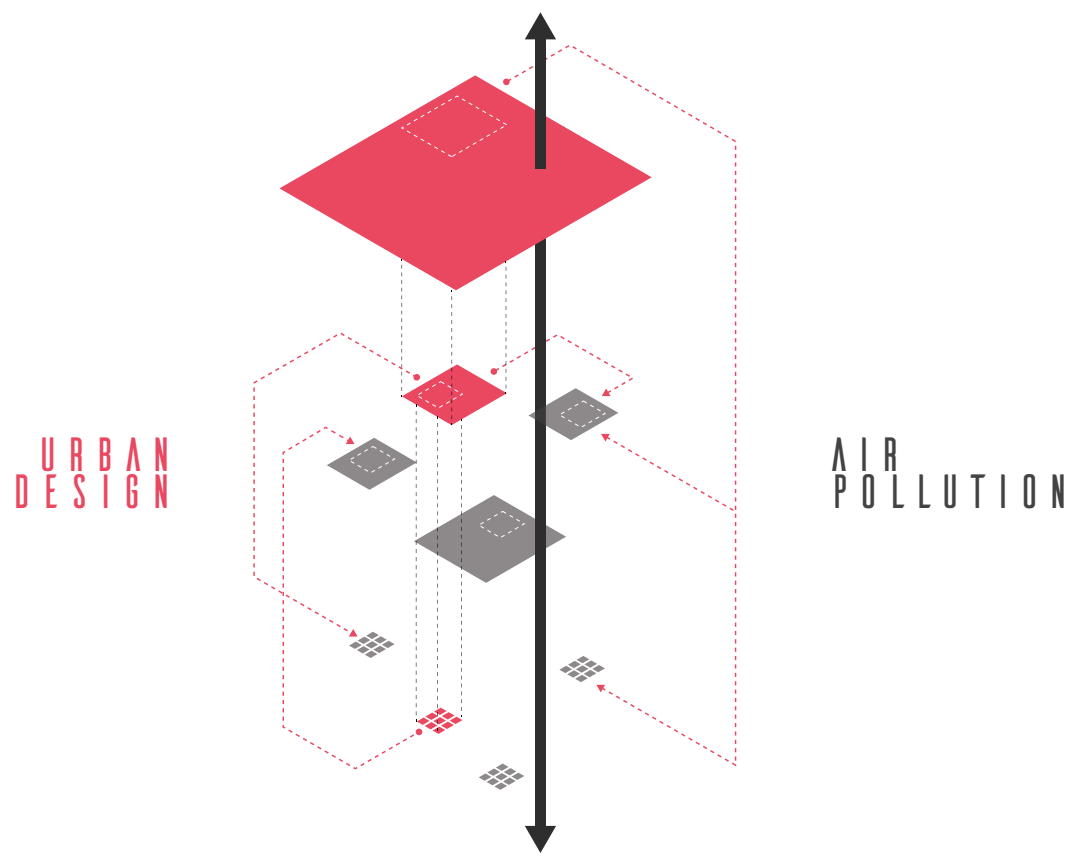
1433
trillion

euros spent in Europe
as consequences of air
pollution



Scope

The city of Turin has been fighting against high levels of air pollution for years. However, despite the application of several urban policies and strategies, the situation has slightly changed and the threat of the issue calls for alternative solutions. The scope of the graduation project is that of understanding the relationship between air pollution and urban design. Consequently, discovering what elements of the urban tissue affect air pollution and how they are related to each other can highlight which scales of urban design address air pollution. Both urban design and air pollution can be considered as interscalar entities. Air pollution behaves and has different effects according to the considered scales; as urban designer, we work through different geographies, temporalities and scales. Overall, the graduation project aims to build an interscalar approach able to tackle air pollution at different scales. Therefore, it tries to cope with three main scale of action: the public space, the street scale and the block scale. If considered together, they can form a thorough system of design solutions able to mitigate air pollution in the city of Turin.



Analysis and risk assessment

A deep analysis of the layers related to air pollution led to the definition of a risk map upon which the choice of the sites of intervention is based.

Hazard and Vulnerability

The concept of risk is related to many theories and approaches. The graduation project focuses on the risk-hazard approach which relies on the concepts of hazard and vulnerability. Vulnerability can be seen as "an inherent property of a system arising from its internal characteristics" (Adger, 1999; Adger and Kelly, 1999). The hazard can be described as a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation (UN, 2004). There is a parallelism between the concepts of hazard/vulnerability and sources/receptor site.

Risk assessment

As results of the risk assessment, it can be noticed that the majority of the vulnerable areas lay towards the periphery of the city where population density is higher and most of the youngsters and elderly live. Surprisingly, the center of the city fits among the areas with the lowest risk factor, that is due probably to strong presence of commercial activities and offices, but also to the traffic limitations rules that the municipality has been implemented during the past years. However, vibrant public spaces such as squares and touristic spots remains some of the most vulnerable.

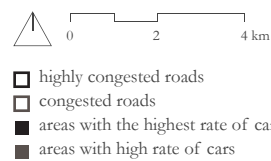
Scales definition

Keeping in mind the scope of the project which is that of mitigating air pollution through an interscalar approach. To this extent, the risk assessment not only reveals which are the most vulnerable areas in terms of air pollution but it also contribute to define the scale of actions. Air pollution, as part of the urban microclimate, can be described through two main scales: the mesoscale and the urban canopy scale. The first one represents the larger climatic conditions of the boundary layer (the layer of air in the immediate vicinity of a bounding surface) of the atmosphere. The urban canopy, on the other hand, represents the microscale phenomena happening at streets level and it is different from road to road. Since architects and urban designer work with more than two extreme scales the risk assessment gives us the tools to decompose the phenomenon of air pollution and reveals the multitude of scales which can affect and be affected by air pollution which vary from the public space of a single square to entire neighbourhoods.

Hazards



Vulnerability



Problem analysis

Richard Oke, in his book *Boundary Layer Climate*, describes pollution within three steps: sources, dispersion and receptor site. A source can be described as a point of origin or procurement - a generative force, the dispersion is the act or process of dispersing and finally the word "receptor" comes from the field of biology and it is defined as an organ or cell able to respond to light, heat, or other external stimulus and transmit a signal to a sensory nerve (. The city and its inhabitants can be seen as the organ and cells able (or not) to respond to the external stimuli, the pollutants. The problem analysis follows the above mentioned stages of pollution.

Main sources of pollution in Turin and its surroundings

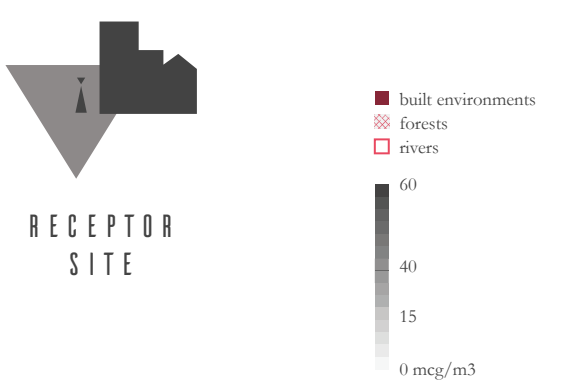
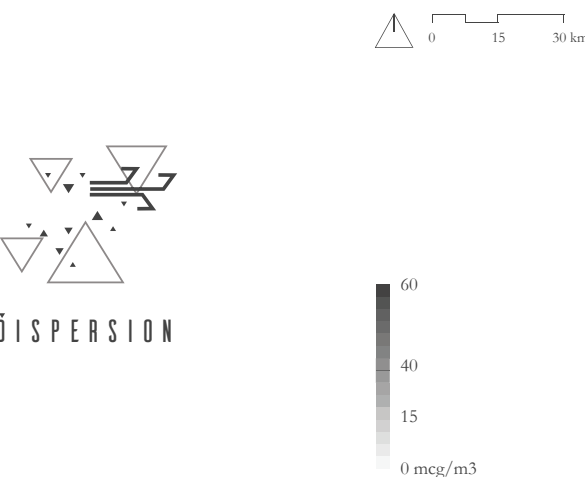
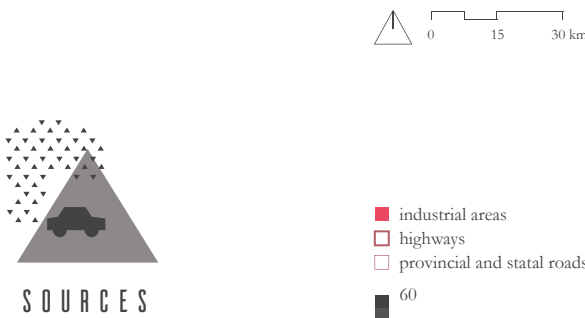
The main responsible of air pollution in Turin are the Particulate Matter and the Nitrogen Dioxide. When looking at the province of Turin, the main sources of pollution are industries and transportation but, as far only the municipality of the city is concerned, transportation is the main cause.

Factors which influence pollution dispersion

Atmospheric motion serves both to diffuse and to transport air pollutants. As far as wind flows are concerned, Turin's average year speed is about 2 m/s and, coming mostly from north-east, is almost non-existing. That is mostly due to Turin's geographical position: the city lays on a basin, surrounded by Alps from North and hills from east; the deep difference in height slows dramatically down winds speed and create perfect condition for air to stagnate. Consequently, either dispersion or transportation of pollutants are not consisting and pollutants stay in the air for long periods.

Receptor site and urban policies

The link between the built environment and air pollution is clear. High concentrations are mostly related to human activities, which happen to be in urban areas. The municipality of Turin has been promoting several policies and guidelines in the past ten years: the integration of bike and car sharing, zone 30 (area with 30 km/h as maximum speed allowed), ZTL (area where car can not drive during rush hours) and several other initiatives.



0 15 30 km

0 15 30 km

0 15 30 km

Nitrogen Dioxide

Particulate Matter 10

Particulate Matter 2.5

Average wind speed

2.06 m/s

Car sharing

Bike sharing

Speed control

Public transport

Design interventions

The research question of the graduation project is:

How can Urban Design mitigate air pollution in the city of Turin?

The research question tries to discover the relationship between air pollution, the built environment and urban design. The link between urban design and air pollution is established within the analysis and the risk assessment. Moreover, the latter also reveal the scales of urban design that address air pollution.

Three scales of action

The graduation project focuses on three main design interventions. Keeping in mind one of the main goals of the project, which is that of understanding the interscalarity of the phenomenon of air pollution and urban design, the interventions try to cope with different scales: micro-scale (public space), block scale and neighborhood scale. Combined to each other they are able to build a thorough and define the urban scale.

Design Approach

The design for each site can be divided in four main stages: analysis, design, evaluation and implementation. In general, each design intervention relies on an in-depth research concerning existing principles or design solutions able to mitigate air pollution. By the combination of design principles and site analysis, design proposal were formulated and consequently tested with EnviMet, a simulation software.

Definition of sites of intervention

The three site of intervention, by focusing on three different scales they also cope with different issues.

The walls

The design is placed in Piazza Vittorio, one of the biggest and most important square in Turin. The chosen square represents an opportunity for dealing with the micro scale of the city and trying to understand the relation between air pollution and public spaces.

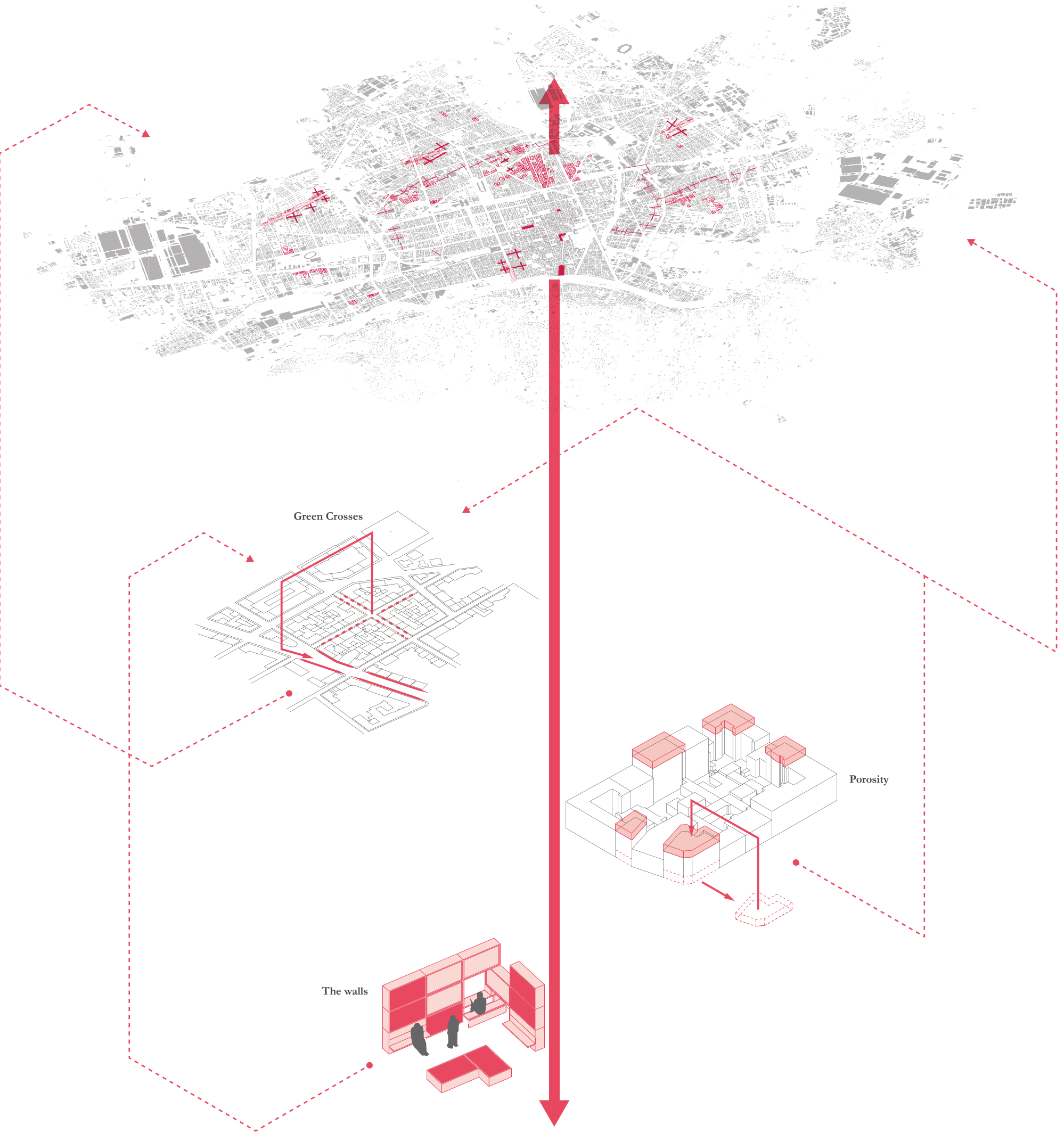
Porosity

The design works with the basic unit of the existing urban tissue: the closed block. It tries to provide alternative solutions both for mitigating air pollution and adding new spatial quality to the existing urban structure.

Green crosses

The design is situated in Barriera di Milano, one of the peripheral areas of the city. It tries to deal with the neighborhood scale by providing public spaces and green areas to its inhabitants.

Combined together, the design proposal form a thorough design approach able to mitigate air pollution.





The walls

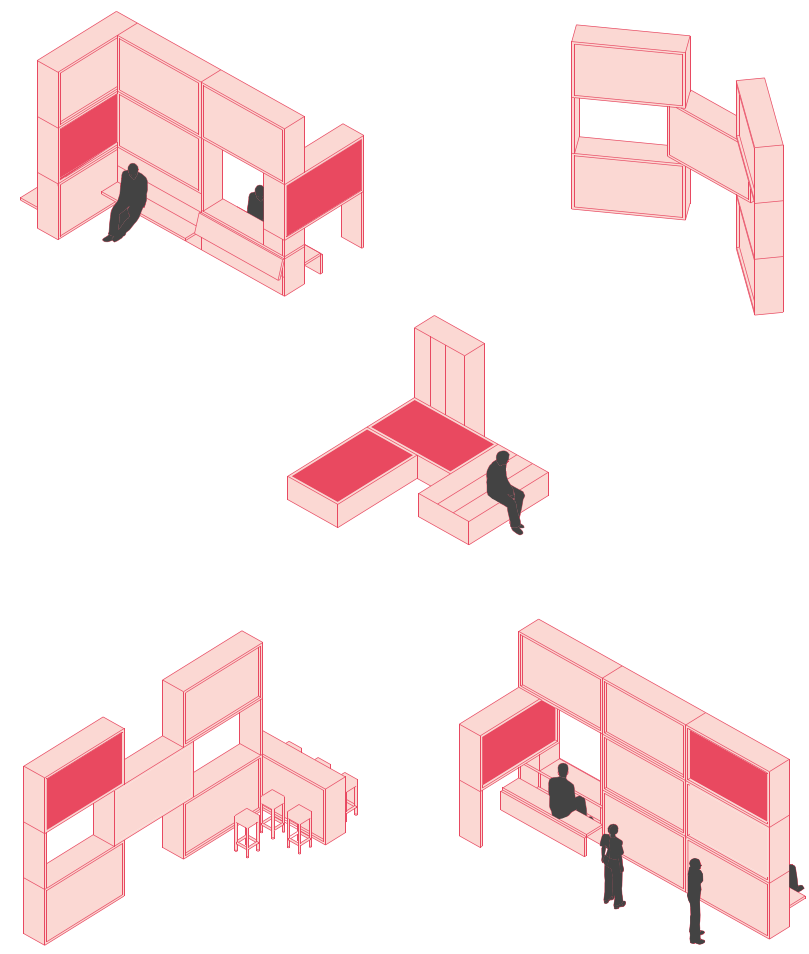
The design lays his basis on the technology of the CityTree, a green wall composed by moss culture able to clean the air by reducing Particulate Matter and Nitrogen Dioxide.

The intervention consists of designing modular elements that, combined with each other, are able not only to mitigate are pollution but also to add spatial quality to the square.

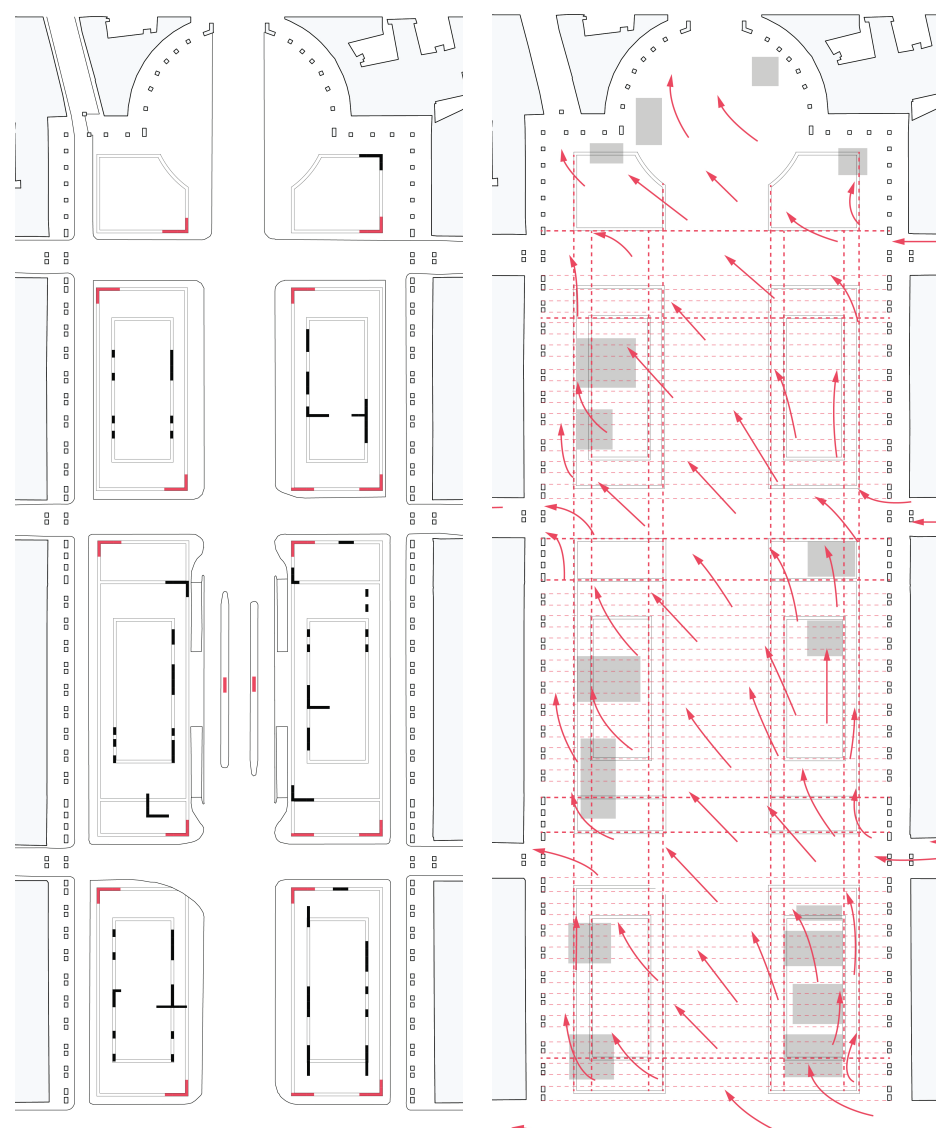
Piazza Vittorio has always been a vibrant public space, its arcades host several commercial activities such as pubs, restaurants and shops which give the place a strong attraction force. In special occasions the square hosts concerts and manifestation.

The walls are therefore designed to be a flexible, temporary and extremely adaptive design. Its modularity allows it do be used for several uses and can create different atmospheres: from a public space composed by benches, working places with Wi-Fi and electricity connection, to cozy green living room for the restaurants and bars of the square.

The position of the walls has been carefully decided taking into consideration several factors. *In primis*, wind flow patterns and air pollution dispersion have been analyzed and showed how and where pollutants are transported. Social and spatial factors such as the current uses of the square and the geometry of the square have played a relevant role as well. The combination of these factors led to identification of the best place for the walls' placement. Some of the walls are fixed and cannot be moved since their crucial role in mitigating air pollution. All the others can be moved and adapt.



Adaptive design: fixed and movable walls Design grid: wind flow patterns and pavement



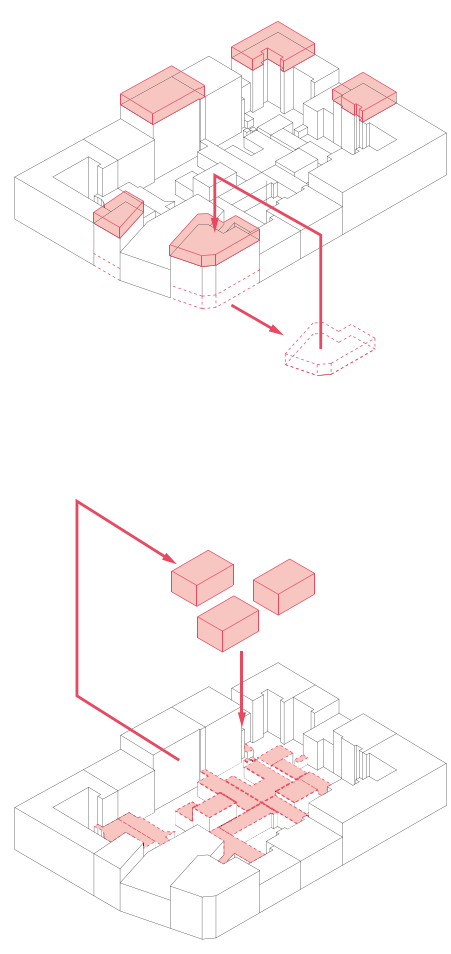
Porosity

The design intervention focuses on the effects of the urban tissue and its units, the blocks, on air pollution. Turin is mostly composed by closed blocks, characterized by commercial activities on ground floors and residences on the upper floors. Thanks to the simulations, several proposals concepts and design ideas have been tested. However, out of the proposals, Porosity is the one which shows the most effective results in terms of air pollution mitigation.

The design consists of removing some of the residential ground floors and to "give them back" on the top of the chosen volumes. By doing that, passages between the inner part of the courtyard and the public realm are created.

Consequently, a new hybrid space, where public and private realm can meet each other, is enhanced.

In general, the success of the design lays on its capability of mitigating air pollution but also of giving new spatial qualities and values to the closed courtyards. For instance, the entrances of the open block can be used as more than a passage towards the inner space of the courtyard: during rainy days they can be transformed and adapted to a covered public space for both youngster and older people. The new added volumes are another important aspect. With the latter, new housing typologies can be implemented and mixed: both high and low income housing could be integrated which might work independently from the existing fabrics. Furthermore, because of the similarities of Turin's blocks, the design might be applied also to blocks in other parts of the city and the design principle concerning air pollution can be used as guidelines for future developments.



Opening the block: increased porosity and mixed use space



Green Crosses

The proposal aims to provide and promote the transformation of two crossing streets into a "safe" place from pollution for the inhabitants of the neighborhood. The project development can be divided in three main phases.

I phase - Closing the streets

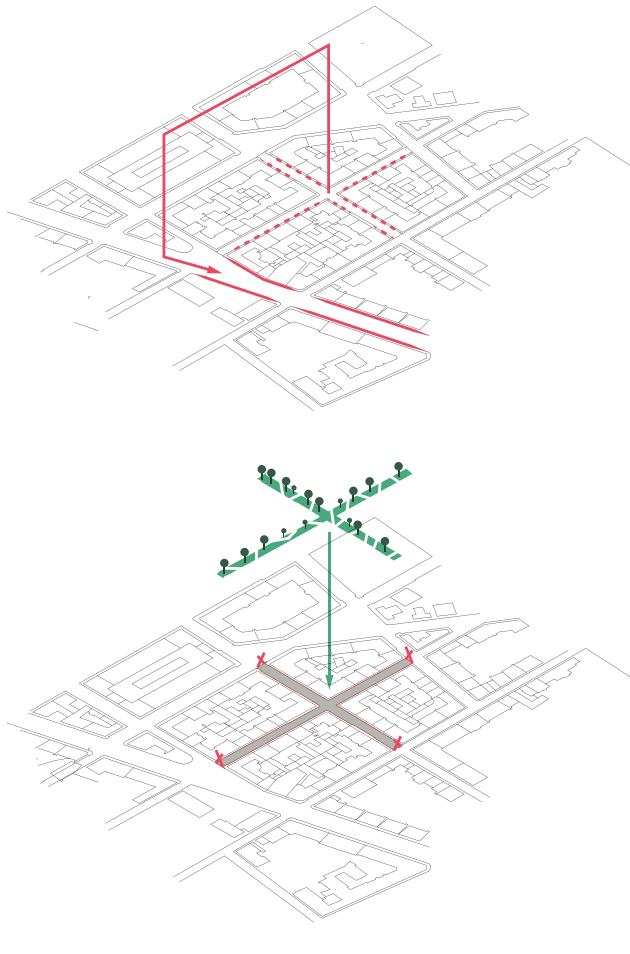
The first phase of the project requires the cooperation between the municipality of Turin and the inhabitants of the area and it is primarily defined by a bottom-up approach. The municipality will close the selected streets to the traffic and will be in charge of relocating the parking places.

II phase - Street gardening

Once the streets have been freed, urban workshops regarding street gardening will be organized in order to encourage inhabitants of the involved streets to start greening the streets. For instance, the municipality will provide the main instruments and tools. Entrepreneurs, owners of commercial activities can use this as opportunity to attract more clients. Overall, this phase of the project is mostly community-based and its success depends on the citizens involvement.

III phase - Transformation

The last phase of the project, depends on the economic availability of the municipality and it would bring to an end the complete transformation of the street to crossed-linear pocket garden.



Design, Linear park

