Reuse of resources in the use phase of buildings. Solutions for water

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Introduction

- **Circular economy** can be considered not only in relation to building construction materials, but also in relation to **resources** that are used in the use phase of buildings.

- The relationship between these resources is inseparable and the nexus energy-water-food is currently recognized as the essential connexion for the sustainable development of mankind.

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Introduction

- The importance of the interdependence between water and energy, also known as the **water-energy nexus**, is well recognized even in **urban environments**.
- Water is crucial in the production of most forms of energy and energy is needed for the urban water cycle and domestic hot water heating. **Water and energy** are also closely **linked with food**.

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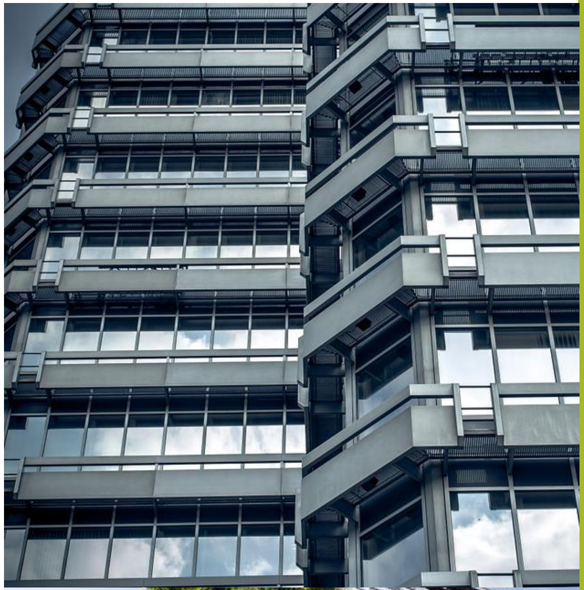
Introduction

- **Zero-energy buildings** have begun to enter the reality of cities in many parts of the world and the next steps should be the design and dissemination of **zero-water and zero-nutrients buildings**.
- On the other hand, some **constructive solutions** are becoming increasingly important in the current scenario of **climate change**, taking into account the need to increase the **resilience** of the urban environment and the **mitigation** of emissions.



Introduction

- Therefore, **zero-buildings** must integrate and enhance these constructive solutions that climate change will impose in the near future and must take into account the intrinsic relationship between **water, energy and nutrients** in urban environments, favouring an integrated approach.

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Zero-water and zero-nutrients buildings

- In the case of **energy**, the concept of zero-energy buildings does not mean a circular use of the resource, but rather that the total amount of resource used by the building is approximately equal to the amount of **renewable resource** produced or available on the site.
- In the case of **water**, part of the resource can be used in a circular way (water recycling), but alternative renewable sources such as rainwater can also be considered.
- In the case of **zero-nutrient** buildings, the resource shall be considered to be circular.

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Basic principles for design of zero-water buildings

- The design of **zero-water** buildings should be based on the **5Rs** principle of efficient use of water, which can be summarized as follows:

5Rs

- Reduce consumption
- Reuse water
- Reduce losses and wastes
- Resort to alternative sources
- Recycle water

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The importance of the recovery and reuse of nutrients in buildings

- The **recovery of minerals** from wastewater is ever more important. Phosphorus recovery (P), for example, is at the top of global political priorities, as shown by the European Parliament statement of May 24, 2012.
- Phosphorous is a unique non-renewable chemical element that is required for food production. About 90% of the world's P reserves are in China, USA, Russia and Morocco, where it has been estimated that today's recoverable reserves will be depleted within the next 30-40 to 300-400 years. These estimations diverge due to uncertainty regarding the volume and quality of global reserves, and to the accuracy of estimates for future demand.

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The importance of the recovery and reuse of nutrients in buildings

- Although the recovery of phosphorus constitutes an emergency in view of the security of food supply in Europe and pollution problems, its elimination through urine is one of the principal causes for the loss of the value chain.
- The recovery of phosphorus in wastewater treatment plants is theoretically possible, but recovery at the source, i.e., in buildings, would have numerous advantages by reducing the load on the treatment plant, avoiding dilution and minimizing the costs and energy consumption in the process.

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The importance of the recovery and reuse of nutrients in buildings

- In fact, most of the nutrients evacuated by man are found in urine.
- Therefore, using urine directly for agricultural purposes has already been the subject of pilot projects in South Africa, China, Germany and Sweden.

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The importance of the recovery and reuse of nutrients in buildings

- The separation of urine in buildings, with or without recovery of phosphorus, requires a revolution in our traditional bathrooms: urine separation toilets, urinals for residential buildings and their generalization to females, etc.

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Built environment and climate change

- An important impact of climate change that is expected to intensify in the next decades is the increased intensity and frequency of heavy rainfall and other extreme weather events, such as heat waves.

- The increase in rainfall intensity is expected to lead to enhanced transport of pollutants and will also more often overload the capacity of sewer systems and wastewater treatment plants.

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The contribution of buildings to climate change mitigation

- Around the world, it is estimated that the building sector contributes as much as a fifth of total global annual greenhouse gas emissions, making buildings the largest contributor to global greenhouse gas emissions and also consuming more than 32% of global final energy.
- The major causes of this contribution are the extensive use of fossil fuel-based energy for thermal comfort, lighting, water heating, water supply and drainage, electrical equipment and appliances, as well as in the production of construction materials.

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The contribution of buildings to climate change mitigation

- The use of green roofs and living facades on buildings can bring great advantages, not only in terms of mitigation but also in terms of increased resilience and adaptation, since it reduces the flow of surface water and increases the number of green infrastructures, in addition to all its associated benefits.
- Green roofs can provide multiple benefits for air quality, mitigating excessive heat and enhancing biodiversity.

The contribution of buildings to climate change mitigation

- Taking into account the urban water-energy nexus, reduction of water consumption in the building cycle is also reflected in significant energy efficiency, considering the reduction of energy consumption needed to heat sanitary hot water and to pressurize water in buildings.
- This is also reflected in public systems (in the abstraction) pumping, and in the treatment of water and wastewater.
- Therefore, the **nexus between water efficiency and energy efficiency** should be one of the most important aspects that must be noted when considering the contribution of buildings to mitigation strategies.

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The contribution of buildings to climate change mitigation

- A study carried out in Portugal by the ANQIP in a medium-sized city (Aveiro) found that energy savings due to the use of efficient products allow a reduction in emissions higher than 100 kg of CO_2 per capita and per year, in relation to the present scenario, taking into account only the heating of domestic hot water in buildings and energy consumption in public networks.

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The contribution of buildings to climate change mitigation

- The reuse of greywater and rainwater harvesting can also contribute to reducing energy consumptions.
- Compact installations for direct reuse of greywater and reducing water consumption in the building, also lead to the saving of water and energy in the urban water cycle.

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The contribution of buildings to climate change mitigation

- As rainwater harvesting systems also reduce water consumption in houses, they additionally entail reductions in water flows and energy consumptions in public networks.

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The contribution of buildings to climate change mitigation

- With regard to large installations for greywater reuse, with the "conventional" treatment for this type of water, we find that the energy consumed in the treatment makes the system "neutral" from an energy standpoint, i.e. the energy expended in the treatment of greywater, about 1.8 kWh/m^3, is close to the energy saved in the urban water cycle.
- However, since the temperature of greywater from showers, for example, is generally above 30 °C, the utilization of this thermal energy for pre-heating hot water will allow a saving of about 3 kWh/m^3, making these installations advantageous not only from the point of view of saving water, but also from an energy standpoint.

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The role of the building water cycle within processes of adaptation and increased resilience

- There are two impacts of climate change that bind directly with building networks of water supply and drainage.

the increased intensity of heavy rainfall	extreme heat waves

- **The construction of green roofs combined with rainwater harvesting systems** in buildings can boost the advantages of each of these technologies, whereby their integration should be considered a very promising solution to face climate change and increase sustainability in cities.

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Discussion and results

- Green roofs, living facades and rainwater harvesting systems in buildings are particularly important constructive systems to address the problems and needs that climate change currently provokes in urban environments.
- They can make important contributions in terms of mitigating the phenomenon and increasing the resilience of buildings, as well as encouraging a circular use of resources in buildings.

Discussion and results

- In a study carried out in Portugal by ANQIP as part of a research project to increase the sustainability of green roofs and living façades, it was concluded that in Mediterranean climates, monthly runoff coefficients are particularly important for sizing the storage tanks of rainwater harvesting systems, in view of the existence of long dry periods, extending in general throughout the summer period.
- In other climates, such as in central and northern Europe, where precipitation periods occur in almost all months, the sizing of the storage tanks is often done on the basis of annual average runoff coefficients.

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Discussion and results

- The **runoff coefficient** is a dimensionless parameter that represents the relationship between the total runoff volume from the roof and the total amount of precipitation in a certain time period and, in impervious roofs, it has a value near one. In the case of green roofs, average annual values of 0.5 for extensive green roofs (with a maximum depth of about 150 mm) and 0.3 for intensive green roofs is generally adopted.
- In fact, these values depend on the characteristics of the roof, such as the type of plants used and the characteristics of the substrate and **are very dependent on the climatic conditions** in the region, especially temperature and precipitation diagrams.

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Discussion and results

- In a study developed in Portugal, in terms of annual averages, the values obtained were a minimum of 0.04 and a maximum of 0.14. It should be noted that these values are clearly lower than the average annual runoff coefficients proposed in the literature for green roofs in central/northern European countries, which sometimes are close to 0.3 for intensive green roofs and 0.5 for extensive green roofs.
- This shows that the integration of green roofs with rainwater harvesting systems still requires significant research, so as to characterize, in each specific region, the design parameters to be adopted.

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Conclusions

- **Circular economy** can be considered not only in relation to building construction materials, but also in relation to resources that are used in the use phase of buildings, such as **water, energy or even nutrients**, like phosphorus. In fact, the relationship between these resources is inseparable, constituting the so-called urban water-energy-nutrients nexus.
- Some of the constructive solutions that should be generalized in the near future to **mitigate climate change or adapt buildings** to their impacts allow a circular use of some resources such as water or nutrients. This is the case, for example, of **green roofs or rainwater harvesting systems.**

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Conclusions

- The combination of these two systems is possible and may enhance the benefits of each.
- But it is necessary to develop further research in this field, as the studies shows that the results depend significantly on the constructive solutions adopted for these systems, and can be different from one region to another depending on local climate conditions.

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- Thank you!

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