Chapter 19
Global Warming: Confusion of Cause with Effect?

Marco Schmidt

Abstract The New Water Paradigm opens up an alternative approach to the climate debate. Rather than explain drought as a consequence of global warming by carbon emissions, this new approach addresses landscape dehydration as a key cause than rather key effect of global warming. The argument is based on the fact that solar energy is converted and a cooling occurs when water evaporates on Earth's surface and water vapour condenses in the atmosphere as clouds.

However, modern urban expansion, global deforestation and desertification reduce evapotranspiration. In turn, reduced evaporation results in increasing short-wave solar radiation which is converted to long-wave thermal emissions and sensible heat. The result is that higher surface temperatures creating heat island effects over cities, contribute to local, regional and ultimately, global climate change challenges. Rainwater harvesting promises a major mitigation strategy against increased temperatures and drought. Urban water management can be enhanced by the ecological design of green roofs, evaporative facades, and ground permeable surfaces combined with vegetation. This paper demonstrates the application of these New Water Paradigm principles in Germany.

Keywords Evaporation • Evapotranspiration • Global warming • Vegetation • Urbanization • Water cycle

19.1 Introduction

The New Water Paradigm explores evaporation challenges and opportunities, leading to a new approach in the climate debate. Rather than explaining drought as a consequence of global warming caused by carbon emissions, it addresses the loss of 800 km^2 of vegetated surfaces as a key cause rather than key effect of global warming. The

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paradigm is designed to reduce the negative environmental impacts of urbanization which form of land use is expanding at 150 km^2 per day. Rainwater management in cities usually means a discharge into drains. Increased city temperatures resulting from radiative heat island effects can be considerably reduced by water evaporation (Schmidt 2009; SenStadt 2010). The new paradigm also reduces flooding and drought.

On a global scale, evaporation lowers temperatures due to the phase change of water into its gaseous state of water vapor. Therefore, the daily loss of vegetation of 800 km^2 globally, 525 km^2 of it represents deforestation (Hansen et al. 2013), damages regional rain cycles leading to a marked shift in average planetary temperatures. At the same time, reduced photosynthesis by plants decreases O_2 output and increases CO_2 levels in the atmosphere. Additionally, the loss of fertile agricultural land (GTZ 2007; Schmidt 2010a) means major food supply challenges. Rainwater harvesting for irrigation and evaporative cooling from soil and plants, therefore represents a major strategy against global warming from a social justice perspective.

19.2 Water and the Global Energy Budget

Evaporation of water is the largest and most important component of energy conversion on Earth. A large portion of rainfall on our surface depends on the rain that evaporates locally. A reduction in evaporation increases the conversion of shortwave global solar radiation to long-wave emissions and sensible heat. A reduction in evaporation on land translates to a reduction in overall precipitation, effecting a further reduction in evapotranspiration, thus creating a dynamic and circular systemic effect (Schmidt 2010b).

Rather than defining evaporation as a water loss, the new paradigm (Kravčík et al. 2007; www.waterparadigm.org) defines evaporation as a source of precipitation. This new perspective fundamentally changes our understanding of global warming. Drought is conventionally expressed as a result of rising global temperatures, but by the New Water Paradigm increased aridity is the cause, not the effect, of global warming. Intensive land use patterns cause local environments to dry out (Ripl et al. 2007; Kravčík et al. 2007), and at the same time increase temperatures.

The tremendous problems resulting from global climate and water challenges are related to unsustainable land use patterns everywhere. For instance in Germany, even though population density may not increase, urbanization continues to grow at a rate of nearly 1 km^2 daily (UBA 2008). This results in an annual reduction of 200 mm evaporation and releases sensible heat and thermal radiation of more than 50,000 GWh (0.2 m^3 $year^{-1}$ * 700 kWh * 1 Mio m^2 * 365 days). In winter, the warming may not be experienced as a negative effect, but certainly it disturbs the stability of weather patterns and cooling in spring, summer and fall seasons. The associated loss of evaporative vegetation further impacts on hydrological processes, causing extreme storms, floods, drought and desertification.

The reduction of evaporative cooling at the Earth's surface increases two components – thermal radiation from long wave emissions and sensible heat. Leaving aside regional climatic differences, Fig. 19.1 using published data from (www.phys-

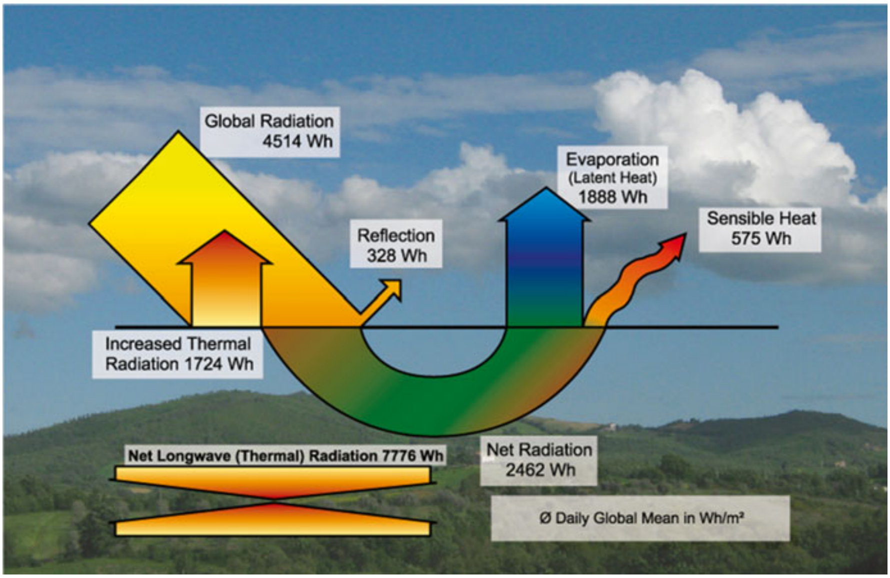

Fig. 19.1 Average global daily radiation budget of one m^2 worldwide (Schmidt et al. 20010a) (Energy data based on www.physicalgeography.net)

icalgeography.net; Trenberth et al. 2009), indicates an average energy flux of one square meter per day across the Earth's surface. The components of incoming solar radiation break down as – 7.3 % reflected and 38 % directly converted to thermal radiation due to the increase of surface temperatures. The total long-wave (thermal) radiation consists of atmospheric counter-radiation (7776 Wh m^{-2} d^{-1}) and the thermal radiation of the surface of the Earth (7776 + 1724 Wh m^{-2} d^{-1}). Other available figures on the global mean energy budget (Trenberth et al. 2009), combine both components, which is scientifically misleading. In Fig. 19.1, the components are presented separately because the process is one of dynamic interaction. All surfaces above −273 °C emit and receive long-wave radiation at the same time.

Net radiation can be either converted into sensible heat (575 Wh m^{-2} d^{-1}) or consumed by evaporation, a conversion into latent heat. Therefore, with 1888 Wh m^{-2} d^{-1}, the energy conversion by evaporation at 42 % from incoming short-wave radiation, is the most largest component of the Earth's energy budget. Furthermore, evaporation reduces the long-wave thermal radiation due to the decrease in surface temperatures.

19.3 From Global to Local Scale

With regard to Fig. 19.1, the global energy budget is dominated by evaporation and condensation. Urbanization results in huge changes to the small water cycle. Hard materials and surfaces in urban areas absorb and re-radiate solar irradiation so

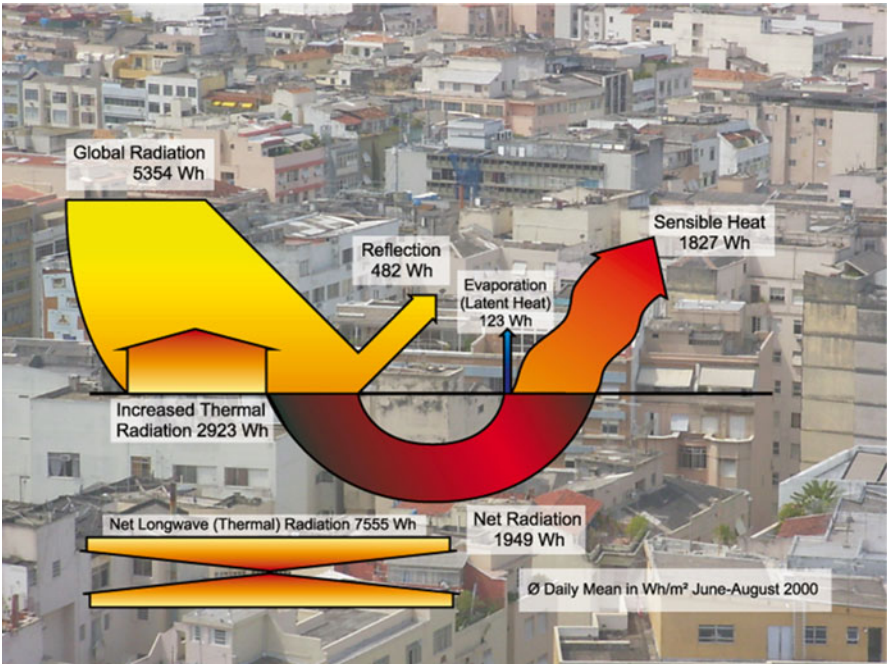

Fig. 19.2 Radiation balance of a black asphalt roof as an example for urban radiation changes (Schmidt 2005)

increasing their heat capacity. The main forces increasing urban heat island effects are vegetation removal and paved surfaces. They influence the urban microclimate through a change in radiation components. As a result, air temperatures inside buildings also rise and leading to greater energy consumption from air conditioning. This worsens the situation of the urban heat island effect by a release of additional heat (Schmidt 2003). To exemplify radiation in urban areas, Fig. 19.2 illustrates the radiation balance of a black asphalt roof. Because rainwater is funneled into sewer systems, most of the net radiation from the urban setting is converted to sensible heat rather than evaporation. Higher surface temperatures also increase thermal radiation.

The option to green buildings is a logical solution to create healthy and sustainable air temperatures in cities and improve microclimate. Vegetation on and around buildings converts solar radiation into latent heat by evapotranspiration. The conventional approach to green buildings focuses mainly on energy conservation and ventilation requirements to reduce CO_2 emissions rather than on the strategic use of vegetation to promote the evaporation process.

According to measurements taken at the UFA Fabrik case study in Berlin, a vegetated roof covered with 8 cm of soil compared to an asphalt roof in the same overall environment transfers 58 % of net incident radiation into evapotranspiration during the summer months (Fig. 19.3). The annual average energy conversion of net radiation into evaporation is 81 %, the resultant cooling-rates are 302 kWh m^{-2} $year^{-1}$

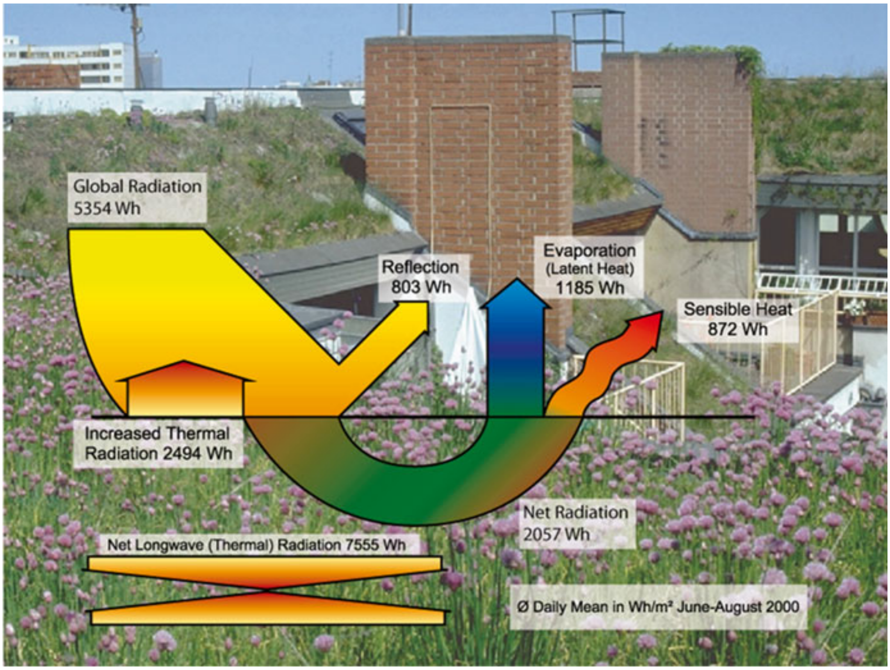

Fig. 19.3 Extensive green roofs transfer 58 % of net radiation into evapotranspiration during the summer months, UFA Fabrik in Berlin, Germany (Schmidt 2005)

with a net radiation of 372 kWh m^{-2} $year^{-1}$ (Schmidt 2005). The asphalt roof and the green roof in Figs. 19.2 and 19.3 have been monitored at the same time in the same location and are directly comparable.

19.4 Global Warming: Confusion of Cause with Effect?

Global temperatures are strongly affected by vegetation, evaporation and condensation. Vegetation also relates directly to O_2 and CO_2 in the atmosphere through photosynthetic processes. Carbon emissions are not responsible for the increase of CO_2 in the atmosphere; the cause of the CO_2 rise is a reduction in photosynthesis. The correlation between rising global temperatures and increasing CO_2 is not a direct one.

Commenting on the social construction of public policy, Salleh (2010, 2016) has noted a trend to carbon reductionism among neoliberal governments and scientific establishments. This reductive thinking translates physical units into economic measurements leading both politicians and global climate activists away from holistic, integrative, environmental solutions for climate change. The turn away from systemic cause-effect dynamics must be corrected if global warming is to be mitigated.

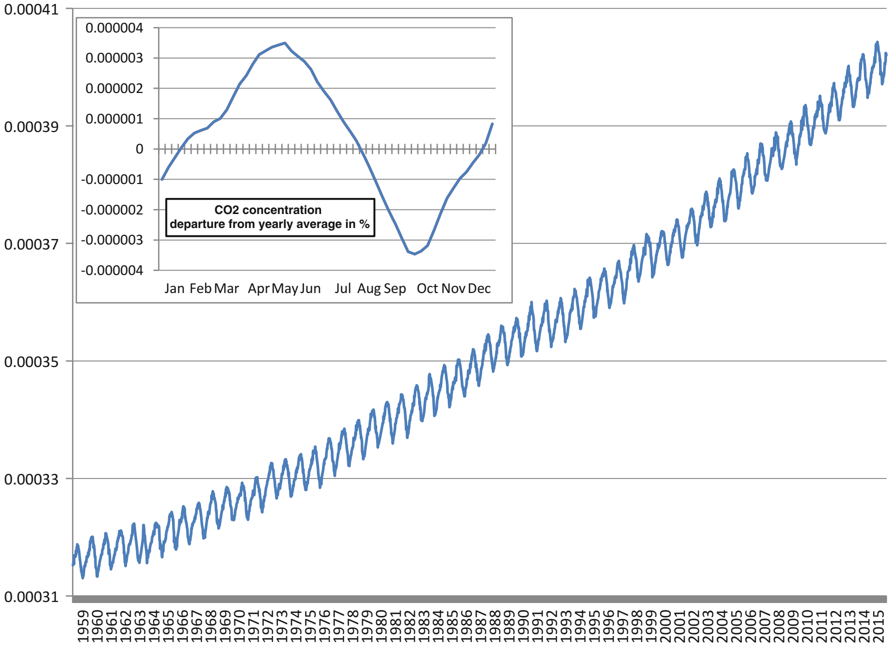

Fig. 19.4 Change in concentration of carbon dioxide in Earth's atmosphere (Keeling Curve), measurements taken at the Mauna Loa in Hawaii. Data from Dr. Pieter Tans, NOAA/ESRL and Dr. Ralph Keeling, Scripps Institution of Oceanography; http://scrippsco2.ucsd.edu

Climate change mitigation measures based on carbon reductionism like using biomass for heating may have the opposite effect than intended. Likewise, trading in carbon emissions is more beneficial to market economics than ecological science. At an epistemological level, ecological cycles cannot be understood by linear reasoning but need to be explained as dynamic interactive processes.

In terms of real measurements of CO_2 in the atmosphere, the longest time period of data is available from Mauna Loa Observatory in Hawaii (Fig. 19.4). We have to consider a continuous increase since the 1960s from 310 ppm (0.031 %) of up to 400 ppm today (0.04 %). Looking closer at the graph in Fig. 19.4, we find an annual cycle. As argued correctly in Al Gore's movie "The Inconvenient Truth" and further popular publications, this annual cycle is related to the change in photosynthesis of vegetation in the northern hemisphere. CO_2 reduces in the spring in April, whereas in October, when plants loose their leaves, CO_2 level again increases. The annual CO_2 cycle clearly expresses the photosynthesis process, but the overall increase since 1960 is being attributed to anthropogenic carbon emissions. This is a misinterpretation. Already Keeling 1960 concluded that "since the seasonal variation in concentration observed … is several times larger than the annual increase, it is as reasonable to suppose, however, that a small change in the factors producing this seasonal variation may also have produced an annual change …".

The reason why anthropogenic carbon emissions are a non-satisfying explanation of CO_2 increase involves ecological dynamics. The dynamic cycle of CO_2 in the

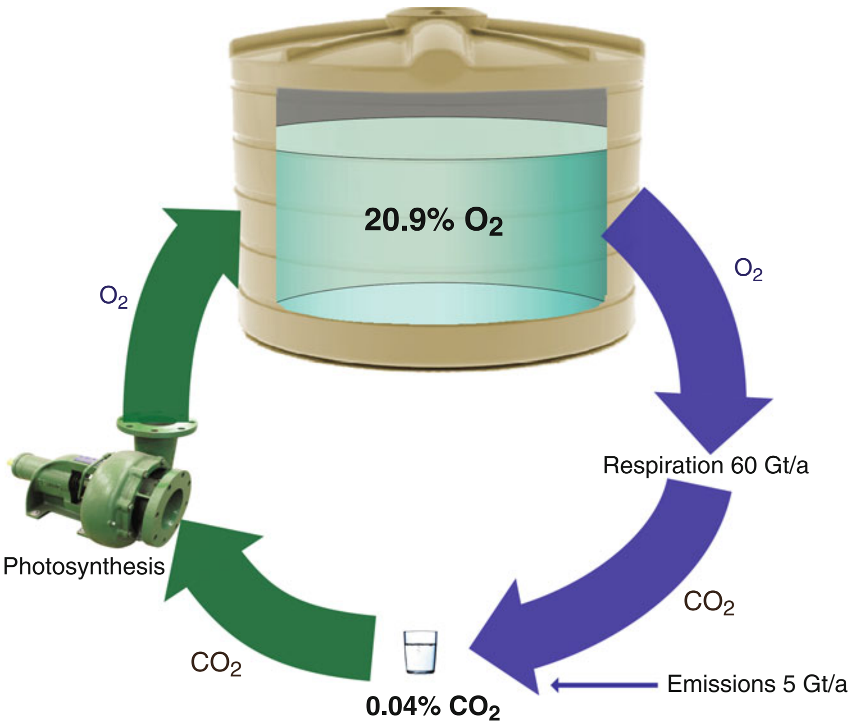

Fig. 19.5 Relation between O_2 and CO_2 by analogy with two types of water storage

atmosphere has its counterpart in oxygen O_2. The rate of CO_2 is 0.04 %, whereas O_2 has a concentration of 20.9 %. O_2 has a much higher energetic level and humans gain their energy by breathing O_2 and releasing CO_2.

To illustrate the ecological cycle in a dynamic way, we might explain the relation between O_2 and CO_2 by analogy with two types of water storage, a small glass which represents CO_2 on the ground floor of a building and a huge tank on top of the building which represents O_2 (Fig. 19.5). The large tank leaks a bit, converting O_2 into CO_2, in ecology this we call respiration. In between the elements we have a huge pump that puts water out of the small glass into the huge tank above. The pump represents the photosynthesis process. The pump is largely oversized, the relation of CO_2 and O_2 is 0.04–21 % instead of say 10 % for both elements. Therefore it is not relevant how much CO_2 is put continuously into the glass. The problem therefore is not CO_2 emission, how much additional water is released into the small glass of water on the ground floor, the problem inheres in the performance of the pump! Therefore globally, the relation between CO_2 and O_2 will always favor CO_2. When the pump finally fails, the Earth will end as it started several million years ago at a range of fully CO_2 and zero O_2.

It is reasonable to acknowledge that emissions play a role in the dynamic cycle at a relation of 10 % of CO_2 and 10 % of O_2. But in a relation of 0.04–21 % the dominant factor for the change in the dynamic process is the reduction in photosynthesis, not any emissions.

19.5 Sustainable Water Management – Case Studies

Implementing the New Water Paradigm at a local level requires rethinking urban planning and water management infrastructures. With regard to the urban heat island effect and the issue of global warming, urban planners, architects and landscapers need to consider the natural water cycle, including evaporation, condensation and precipitation (Milosovicova 2010). The conventional management of water discharge, which was implemented for over a 100 years, nowadays bears disastrous environmental effects on both surface water quality and on the climate. More recently, rainwater infiltration has been a popular strategy in Germany. However, in spite of the great benefit of preventing negative impacts to surface waters, infiltration does not fully rectify the natural water cycle. Urban areas are not characterized by reduced infiltration rates (SenStadt 2013). The missing hydrological component is evaporation.

In the catchment area of Berlin/Brandenburg, about 80 % of precipitation is converted to evaporation, while groundwater recharge and runoff together represent 20 %. Urban areas are characterized by completely paved or semi-permeable surfaces with little to no vegetation. The semi-permeable surfaces allow much higher groundwater recharge compared to naturally vegetated areas (Schmidt et al. 2005), as they over-compensate for infiltration with reference to completely paved surfaces. Therefore, in the interest of effective environmental care taking, the provision for evaporation rather than infiltration needs to become a primary task.

Through urban design strategies such as green facades, green roofs and stormwater ponds, rainwater harvesting cisterns can play supportive roles as adaptation and mitigation strategies against the urban heat island effect and global warming. By applying the New Water Paradigm (see www.waterparadigm.org) small local water cycles are restored. Harvesting rainwater for evaporation should be a first priority in urban areas. Already several projects have been established in Berlin with a focus on rainwater harvesting and evaporation, of which two are presented here – UFA Fabrik and Potsdamer Platz.

19.5.1 Case Study 1: UFA-Fabrik in Berlin-Tempelhof

The Cultural Center UFA-Fabrik in Berlin-Tempelhof, home to various urban ecology initiatives (see: www.ufafabrik.de) includes an integrated rainwater management project. As a first measure, most of the roofs were vegetated from 1983 to 1985 (Figs. 19.6 and 19.7). In 1994, a rainwater harvesting system was introduced. As a result, water from conventional and green roofs was able to be stored in a former underground waterworks station, along with runoff from street level.

The rainwater system at UFA-Fabrik has a total storage capacity of 240 cubic meters in two cisterns. This is equivalent to 40 mm or 6.7 % of annual precipitation of the catchment area. The system collects primarily first flush stormwater. By

Fig. 19.6 On top of a Greened roof at UFA-Fabrik Berlin-Tempelhof (Photo author)

capturing the pollutants and nutrients associated with the first flush, UFA-Fabrik with a separated sewer system, provides increased ecological benefits by directing polluted runoff to a modified constructed wetland for treatment. Collected rainwater is used to flush toilets and for irrigation. About 75 % of rainwater used in the summer month is linked to irrigation. This rate of use, the large storage capacity for rainwater, and the greened roofs represent best management practice for the New Water Paradigm.

The constructed wetland (Fig. 19.8) has a size of 25 square meters for a mean treatment of 10 cubic meters per day. This represents a mean treatment value of 400 l of rainwater per day per square meter. Due to the large use of rainwater for irrigation in summer time, the amount of treatment in winter is much less, this corresponds to the treatment efficiency of a constructed wetland during low temperatures. The soil type has been changed twice over the lifetime of the project to improve the treatment efficiency. In preparation for the second case study Potsdamer Platz, several different types of substrate were tested on-site (Fig. 19.8). The substrate which performed best, a mixture of gravel, zeolithe and expanded slade, was selected (see next case study). Soil clogging was dominating factor during the testing period. Finally a grading of 2–4 mm was selected to fulfill the requirements on overall performance.

Fig. 19.7 Green roof combined with photovoltaic panels at UFA-Fabrik Berlin-Tempelhof (Photo author)

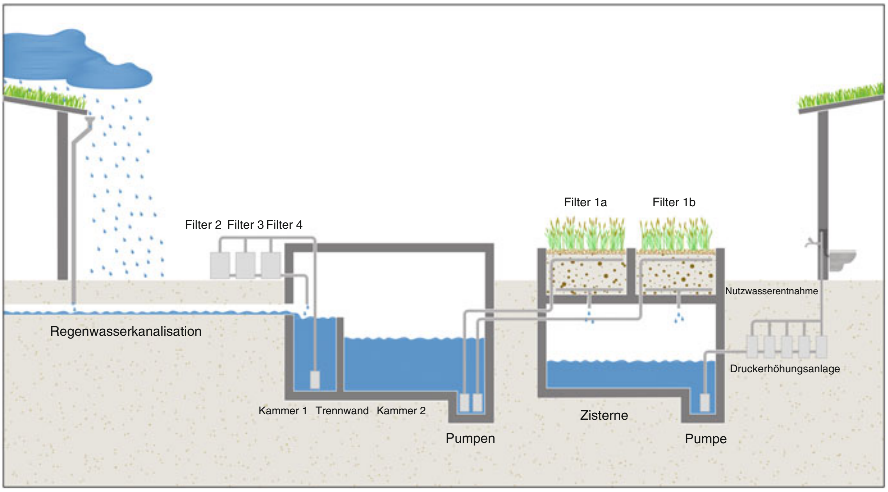

Fig. 19.8 Rainwater harvesting including constructed wetlands for treatment at UFA Fabrik Berlin

19.5.2 *Case Study 2: DCI Berlin, Potsdamer Platz*

The large constructed wetland (Fig. 19.9) and so called urban lake (Fig. 19.10) at Potsdamer Platz are part of an overall concept of sustainable rainwater management set up in 2000. The city administration had demanded a reduction of rainwater run-off into the combined sewer system by 99 % of its intensity during stormwater

Fig. 19.9 Constructed wetland for rainwater treatment of roof runoff at Potsdamer Platz, Berlin (*left*) and its construction in 1998 (*right*) (Photo author)

Fig. 19.10 Rainwater retention by an artificial urban lake at Potsdamer Platz, Berlin (Photo author)

Fig. 19.11 Green roofs at Potsdamer Platz during construction in 1998 (Photo author)

events. The goal was to reduce overload of the combined wastewater sewer. Three measures of sustainable water management were integrated to fulfill this (Schmidt and Teschner 2000). A co-operation between Atelier Dreiseitl, Krüger and Möhrle and TU Berlin combined green roofs (Fig. 19.11), rainwater harvesting and a large urban lake of 12,000 square meters to retain the roof runoff of 46,000 square meters from 17 buildings.

The main function of the constructed wetland is the reduction of nutrients in the urban lake to avoid algae growth (Teschner and Schmidt 2000; Teschner 2005). Water continuously circulates through the gravel filter. Tests for 6 different soil types have been carried out in facilities at www.ufafabrik.de (first case study). Soil clogging was one of the first problems occurring after 4 weeks. The artificial substrate, consisting out of zeolite, expanded slate and gravel, was therefore selected at larger aggregates of 2–4 mm. Water quality in the cascade roofs – cistern – urban lake – circulation tank retains 99 % of its phosphorous load as well as nitrogen (Fig. 19.12). Remaining concentration of phosphorous is less than 15 μg l^{-1} which represents an oligotrophic surface water. Interesting is the phosphorous peak around New Year 2000 due to fireworks (Fig. 19.12). Nitrogen concentration reduces in the cascade cistern – urban lake from 2000 to around 300 μg l^{-1} caused by biologic processes in the tank. Compared to processes in treatment plants, treatment efficiency improves with a long retention time of rainwater in the tank. Additional technical filters in the building complex like a micro sieve give support to the cleaning process. The rainwater concept at Potsdamer Platz is based on a new approach of sustainable water management. Instead of common runoff management based on sewer systems or infiltration into the ground water, this system provides evaporation and rainwater use for toilet flushing.

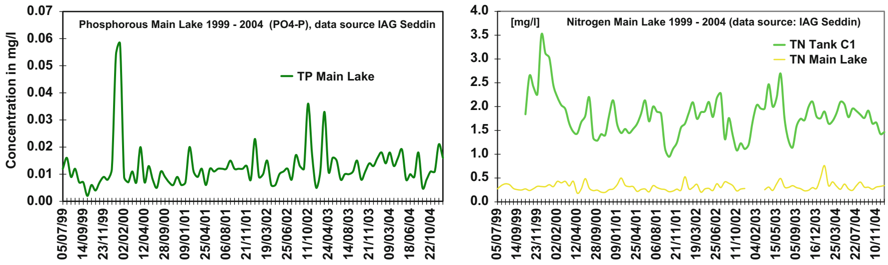

Fig. 19.12 Phosphorous concentrations in main lake (*left*) and nitrogen concentration in rainwater tank and artificial urban lake (*right*) (Source of data: DCI; Meisel, IAG Seddin)

Green roofs are a basic measure for the whole water management concept. Evaporation rates are already 70 % of annual precipitation. 80 % of polluting nutrients are filtered out by soil, moss and weeds. Several different types of substrate were tested at the Technical University of Berlin for best performance on nutrient removal before being spread on all 17 buildings at Potsdamer Platz.

19.6 Conclusion

Attention to vegetation, climate and water seriously challenges conventional climate measures. Rather than focusing on greenhouse gas emissions to address climate change, the emphasis should be on planting trees and improving soils to store more rainwater and by this means to recover the small water cycle of evaporation, condensation and precipitation.

It is not generally realized that the correlation between CO_2 in the atmosphere and global temperatures as shown in ice core drillings and used as a basis for the climate debate is an indirect correlation. Vegetation and its capacities for evaporation and photosynthesis is the driving force behind carbon increase and behind increased temperatures at the same time.

The current increase in CO_2 and other greenhouse gases has no influence on the energy budget of the Earth. Temperatures and atmospheric counter radiation are fully dominated by evaporation and condensation. Condensation takes place inside the atmosphere above the heavier CO_2 gas levels. Thus, the much publicized greenhouse gases actually have an opposite effect to what is claimed regarding the energy release of condensation as part of the water cycle. For the large amount of latent heat released in the atmosphere greenhouse gases reduce counter radiation, therefore reduce the greenhouse effect. All in all, the absorption of a certain wavelength does not mean, that increased concentrations of greenhouse gases increase the long wave radiation of the atmosphere. What has to be considered also, is the question of at which altitude of the atmosphere the energy of the condensation process is released.

The global climate is dominated by evaporation and condensation of water. In the large component of condensation that makes clouds, energy is released as long-wave radiation inside the atmosphere. In additional to the release of 700 kWh per cubic meters of water in the phase change from water vapor to the liquid state, 91 kWh of energy is also released in the phase change of water into ice.

Rainwater harvesting measures which focus on evaporation rather than infiltration have considerable potential to decrease the environmental impacts of urbanization. Under the New Water Paradigm, global climate change is attributed to reduced evaporation (Kravčík et al. 2007). The popular focus on reducing greenhouse gas emissions to mitigate global warming misconstrues of environmental processes. Computer simulations of global climate change continue to neglect the fundamental driving forces of the global climate: transpiration by vegetation and evaporation from land. The importance of plant photosynthesis cannot be underestimated.

The research summarized above proves that evaporation of water is the cheapest and most effective way to cool a building and a city. It is known that one cubic meter of evaporated water consumes 700 kWh of heat. Thus, instead of energy expensive conventional air conditioning systems, which produce additional heat and release it outside the building, the evaporation of water simply consumes heat at low operating costs.

No drop of water should be funneled into sewer systems or pumped into oceans without being used first for irrigation and further evaporation. The worldwide destruction of vegetation, particularly in North Africa and the Middle East has caused droughts and climate change. With the New Water Paradigm, the critical concept is that global dehydration and drought is what causes climate change, not that climate change is causing drought. The correlation between CO_2 and global temperatures in the past was always merely an indirect correlation with vegetation and water. Rectifying climate change environmentally will mean focusing on precipitation, vegetation and soils.

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