FLOATING HOUSES – CHANCES AND PROBLEMS

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A b s t r a c t

The Building Physics is a relatively young discipline making rapid progress. New fields of research are not unusual and one of these should be the floating architecture. In this field the boundary conditions of the climate and the ground are in a great difference to the classic buildings. Chances and risks must be quantified. In context with the climate change worldwide the sea level is rising slowly. Therefore The Netherlands in Europe and some countries in Asia are looking for new housing areas, i.e. for construction grounds to settle the growing population. The water areas of channels and closed down harbours offer a good opportunity to install floating houses. In the same way post-mining lakes and brownfields may be suitable for modern marinas. A lot of new problems are to tackle with regard to the physical and chemical effects of water on the constructions and the room climate. New materials and structures must be developed in order to withstand the attacks of waves, sea climate, salts and ph-values. The use of renewable energies is demonstrated in the floating houses and their floating foot bridges as well as pontoons and dolphin piles by means of heat pipes and circulating water in the facades of floating houses. Three years ago a project was started to these topics. First results of the investigations supported by experiments and numerical simulations are represented in the paper.

S t r e s z c z e n i e

Fizyka budowli jest stosunkowo młodą i szybko rozwijającą się dyscypliną. Cechują ją nowe i oryginalne tematy badawcze, do których można zaliczyć architekturę obiektów pływających. Na tym polu warunki brzegowe związane z klimatem i podłożem znacznie różnią się od tych wyznaczanych dla klasycznych budynków. Szanse i ryzyka muszą być określane ilościowo. W związku z ogólnoświatową zmianą klimatu poziom morza powoli się podnosi. Dlatego Holandia w Europie i kilka krajów w Azji poszukują nowych obszarów do zabudowy tj. gruntów budowlanych do osiedlania rosnącej populacji. Obszary wodne kanałów i zamkniętych portów oferują dobre warunki do tworzenia pływających domów. W ten sam sposób jeziora pogórnicze i tereny zdegradowane mogą nadawać się na nowoczesne przystanie. Wielu nowym problemom trzeba stawić wyzwanie pod względem fizycznych i chemicznych wpływów wody na konstrukcje i klimat wewnątrz obiektów. Nowe materiały i obiekty muszą być konstruowane w taki sposób by mogły przeciwstawić się atakowi fal, morskiemu klimatowi, zasoleniu i odczynowi pH. Przedstawiono użycie odnawialnych źródeł energii w pływających domach, prowadzących do nich pływających pomostach, a także pontonach i pławach, wykonane za pomocą rur grzejnych i krążącej wody w elewacjach pływających domów. Trzy lata temu ruszył projekt związany z tymi zagadnieniami. Pierwsze wyniki badań poparte eksperymentami i symulacjami numerycznymi zostały przedstawione w tym artykule.

K e y w o r d s: **Floating architecture; Building physics; Pontoon; Revaluation; Brownfields.**

1. INTRODUCTION

Floating architecture is gaining significance in the wake of increasing public awareness for new development of waterfront areas. Rehabilitation of brownfields, particularly those of former lignite mine pits, is an expensive undertaking and requires not only technical solutions but the generation and involvement of new ideas.

Floating architecture is a possibility for redevelopment after the closure of opencast lignite mines. It can give impulses for regional development instead of pure rehabilitation of a culture landscape. Moreover, it offers opportunities for the renewable energy source water.

Yet there are a lot of additional problems due to the special climate boundary conditions including wind waves and chemical components of water in case of post-mining lakes. There is a need for studying and solving these problems to avoid damage in future. Direct attacks of the climate components solar radiation and wind owing to the lack of neighbouring buildings or trees on the one hand and the modern glass architecture on the other side cause an uncomfortable room climate in summertime. New materials and structures must be developed in order to withstand the attacks of waves, sea climate, salts and ph-values. The harmonisation between architecture and nature is to discuss. Moreover there are questions about energy and water supply. The managing of waste disposal must be resolved. The safety of children or animals is to be discussed too. In districts with cold wintertime the attacks of ice to the pontoons and the safety of walking on footbridges must be considered.

Floating architecture could be a resolution in future for current problems in many districts, cities and landscapes. Such problems can be seen especially in the need of additional housing areas and construction grounds in some countries in Europe and Asia as a result of the growing population and/or the slowly rising sea level in the context to the worldwide climate change. Another example for problems of current interest is the use of alternative sources of energies. The water areas of channels and closed down harbours offer good opportunities to create new water landscapes with modern marinas consisting of floating houses and other floating architecture. As shown in the paper, the brownfields of former open-cast lignite mines are appropriated for such modern marinas by transformation into post-mining lakes. But there is something to be considered in the use of mining lakes.

2. HISTORY OF FLOATING ARCHITECTURE

The global history of floating houses is very complex ([1], Giebler, 2007). The technique and architecture of these buildings all over the world depend on the climate boundary conditions, the culture and the raw materials, which were available at the different local places, Fig. 1. In Europe the historical situation is relatively simple. At the beginning there were house-boats, which in many cases were originally used as barges, Fig. 2. Asia has a much longer history of floating architecture. Yet owing to the Asian mentality the documentation is very meagre and the records are only rarely available. Figure 3 shows an examples of floating architecture from the past in the canadian forest.

Figure 1.
Floating houses and islands of the former "Madanculture" using the material reed

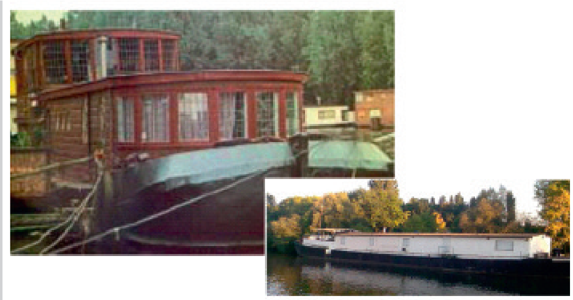

Figure 2.
Examples of converted barges to house boats in Central Europe

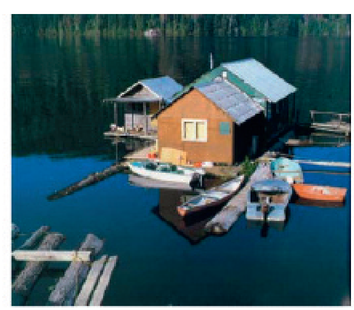

Figure 3.
Floating accommodations of former lumberjacks in Canada

3. CHANCES

The development of life has taken place likely in the environment of water. There was and still is a fairly affection of human beings for water areas. Now it is possible – and in some cases it even seems to be a necessity – to return to the water places. Nowadays the techniques are available to use the properties of water in our favour; this means to use the possibilities of the mobility of floating architecture and the energy resources of the surrounding water areas.

In the following some prospects in context with floating architecture are represented shortly.

3.1. Use of renewable energy resources

The surrounding water can be used for heating and cooling through the year. For this the techniques of evaporation, heat pipes or running water through the building envelopes by use of the buoyancy and minimized pumps are available, see sketch in Figure 4.

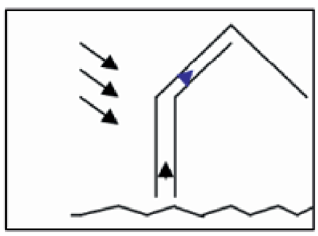

Figure 4.
Moving water in the envelope parts of floating houses by means of the difference in density of water caused by different solar radiation on the facades

3.2. A new feeling

The direct contact with the natural environment of water is a base for an attractive property. Many people would like to spend their life in a floating house.

Figure 5.
Floating house erected in 2009 at a post-mining lake in the Lusatian landscape, Germany (Wilde, 2009)

The Fig. 6 and 7 show examples of the winners of an architecture competition, started in December 2008 by the International Building Exhibition "Fürst Pückler Land"in Germany on the mobility of floating architecture ([2], Feiler & Meditsch, 2008).

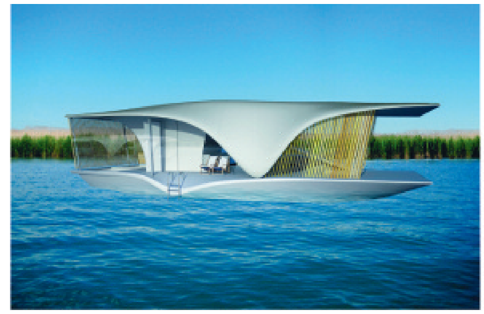

Figure 6.
International competition "Floating Mobile Architecture 2008" Award winner: Rafael Schmidt/ Zürich, Switherland "The last resort"

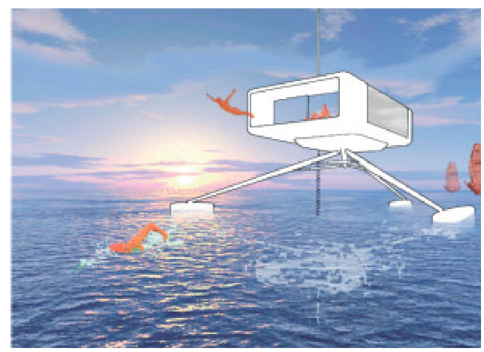

Figure 7.
International competition "Floating Mobile Architecture 2008" Honorary Prize: Eduard Langner/ Walzbachtal, "Hubmodul"

3.3. Additional construction ground

Floating architecture will be a solution for the future lack of construction ground owing to the growing and expanding population of the world. In addition in context with the rising sea level towns of floating houses could be an alternative construction ground, e.g. in The Netherlands and some countries in Asia.

Figure 8.
Marina computer graphic of so-called gothic floating houses at the lake of Geierswalde in the Lusatian Lakeland near to the border of Poland, Germany

3.4. New materials and innovative construction

The construction and materials of floating architecture are subjected to the attacks of water and climate components such as wind waves, salts, solar radiation, humidity and so on. As to the sustainability new materials and composites of them with innovative properties are to be developed and tested.

3.5. Mobility

One advantage of floating architecture over usual buildings is its mobility in view of changing positions or local places. Thanks to it the owner can look for other places as desired and concerning his likings. Besides the subjective component the mobility is an advantageous property with regard to the optimization of the solar energy inputs.

The advantages of a mobile building have a subjective side (everybody can choose a place according to his desires, ideas and technical references) and an objective side (by means of the possible position changes a maximum input of solar energy can be reached). A concentration of the infrastructure on one centralized location in a large district of several lakes connected through so-called channels reduces the costs of supply and waste disposal too.

Figure 9.
Map of connected lakes in the so-called Lusatian Lakeland

3.6. Revaluation of brownfields

The use of the floating architecture in the areas of old docks and post-mining lakes revalue the cities and landscapes in numerous towns and districts all over the world. The flooding of a post-mining lake is a long-term and complicated process.

3.7. Renewable energies

3.7.1. Use of the heat pipe principle

In different versions it is possible to use the phase change energy for transfer of heat energy. For instance Figure 11 demonstrates the heat pipe as a protector against attacks of ice loading in wintertime.

Figure 10.
Revaluation of the former opencast mining landscapes in Lusatia/Germany initiated by the International Building Exhibition IBA "Fürst Pückler Land"

Figure 11.
Test stand for model of dolphin, constructed as a heat pipe

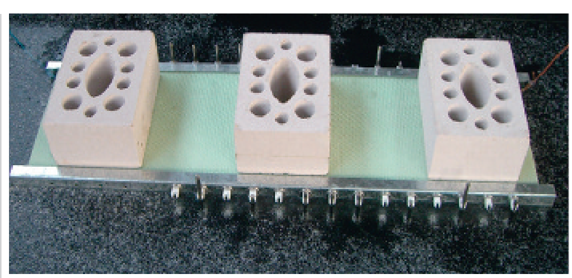

Figure 12.
Foating model for the investigation of steel pontoons to protect against attack of ice by assambled activ and non active heatpipes

3.7.2. Envelopes with flowing water

With regard to the sketch in Figure 4 the graphs in Figure 13 show the difference of pressure caused by the difference of temperature between the facades.

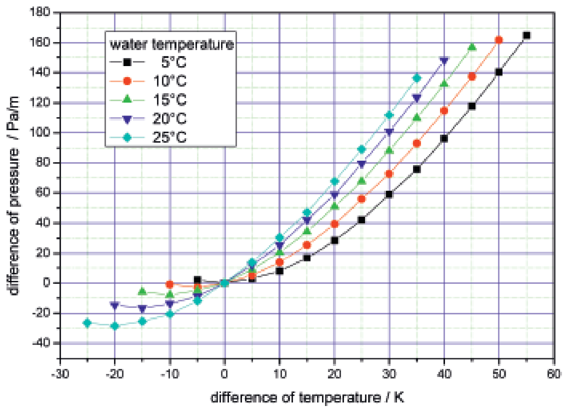

Figure 13.
Differences of pressure between facades of one building with and without solar radiation

3.7.3. Heat exchanger

The heat exchange is strongly dependent on heat transfer and the heat transfer coefficient in water differs considerably from that in air. The position of the heat exchanger also plays a role regarding to the flow conditions.

Figure 14.
Experiments with regard to the investigation of an optimisation of the heat exchange in surrounding water

Figure 15.
Fitting of heat exchanger in the pontoons for cooling and heating of the floating house according to Fig. 5

4. PROBLEMS AND RISKS

However there are a lot of problems due to the special environment of water and its physical and chemical properties. Some problems of floating houses and their floating bridges are listed now.

4.1. Local climate

The construction of floating house is subjected to stronger external loadings due to the increased attacks of wind, wind waves, driving rain, ice and solar radiation. Floating houses should be reached safely in winter time too, Fig. 16, 17.

Figure 16.
Floating bridges of the diving school on lake "Gräbendorfer See" during wintertime. German district Lusatia, near the border with Poland

Figure 17.
Frozen lake "Partwitzer See" – in the German district Lusatia

4.2. Indoor climate

There is no problem to improve the heat insulation in the cold season in case of strong winter climate, e.g. by an increased intensity of wind. But during summertime innovative solutions are necessary in order to guarantee a moderate indoor climate. Users demand a comfortable atmosphere in spite of more and more glass architecture (Fig. 18), no plants and neighbouring buildings, reflected radiation and difficulties with use of blinds caused by more and intense wind.

Figure 18.
"Ar-che" design with a comprehensive glass architecture ([4], Wilde, 2009), computer graphic of the floating house acc. to Fig. 5

4.2.1. Room climate in the warm season

Fig. 19 shows the issue with regard to the human thermal comfort ([3], Stopp & Strangfeld, 2008).

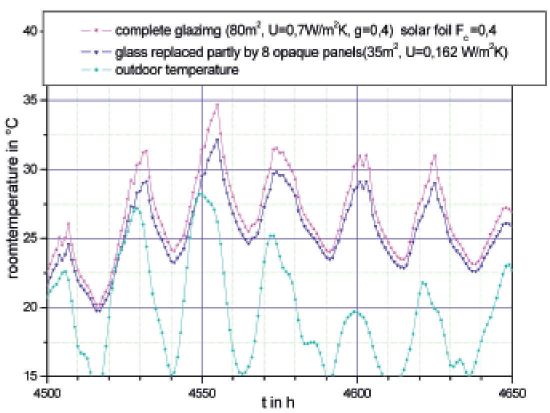

Figure 19.
Course of the room temperature of a floating house acc. to Fig. 18

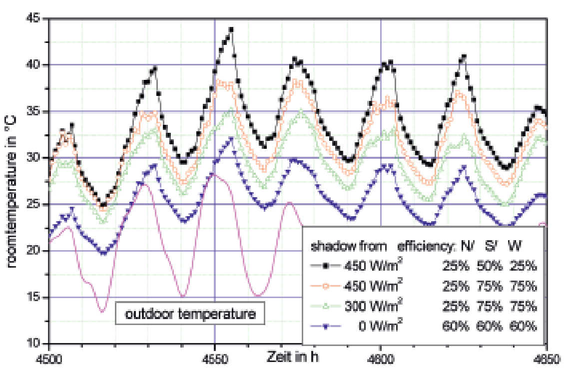

Figure 20.
Floating house according to Fig. 18, glazing replaced partly by 8 opaque panels shaded by 25% bright curtain, 50% indoor blind, 75% outdoor blind, 60% solarfoil applied at the interior surface of window glasses

Figure 21.
Diving school on lake "Gräbendorfer See" in summer-time viewed from the water side

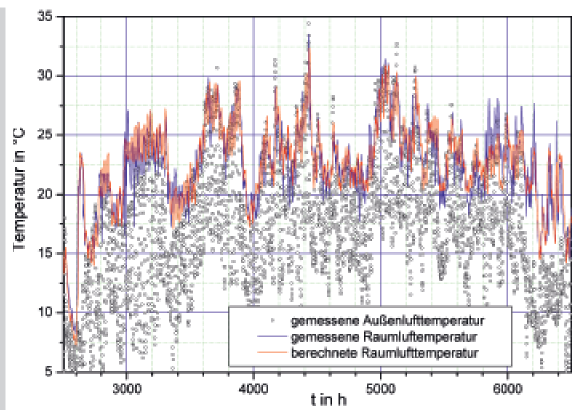

Figure 22.
Comparison between the measured temperature of the bed-room in the floating house acc. to Fig. 21 and the calculated temperature by means of a self-developed software

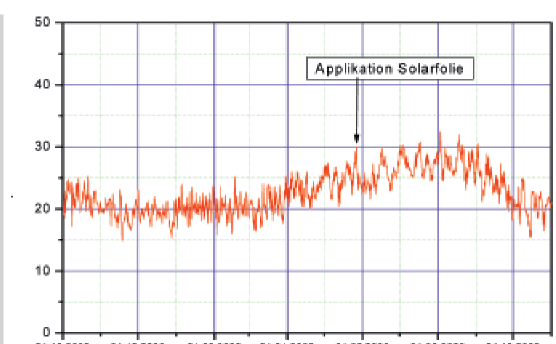

Figure 23.
The course of the temperature in the bedroom of the floating house acc. to Fig. 21 before and after the application of a solarfoil on the window glasses through the whole year

4.2.2. Thermographic examinations

The Figures 24, 25 and 26 show the three floating houses as a thermophysical picture shown before in the Figures 5, 16, 17, 18 and 21 by means of visible radiation. You can recognize the influence of the reflecting mirror of water.

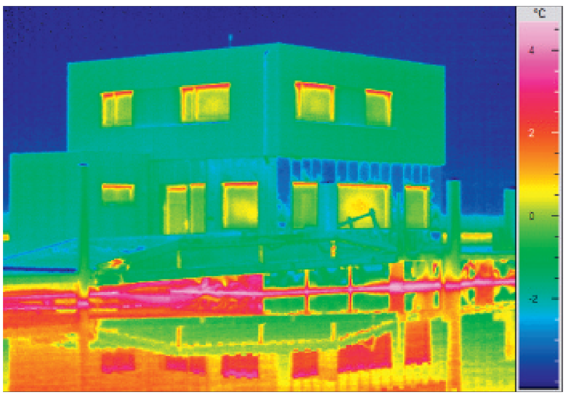

Figure 24.
Thermal image from thermographic examination: see Fig. 16

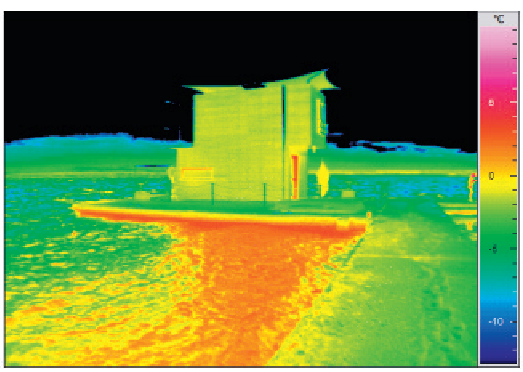

Figure 25.
Thermal image from thermographic examination: see Fig. 17

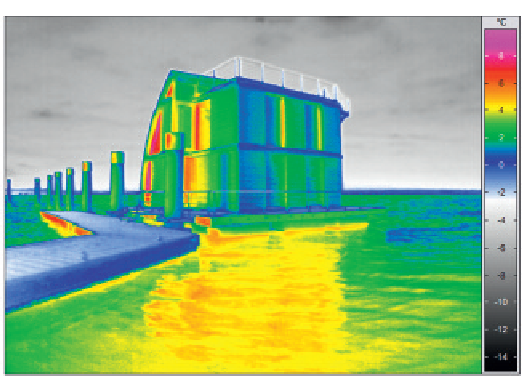

Figure 26.
Thermal image from thermographic examination: see Fig. 5 and 18

4.3. Corrosion of materials

The additional attacks by chemical and physical components of salts, ph-values, ions etc. and the special components of the local outdoor climate effect an intense corrosion of materials. Fig. 9 represents the damage of concrete, which set in already two years after its installation at the lake "Partwitzer See".

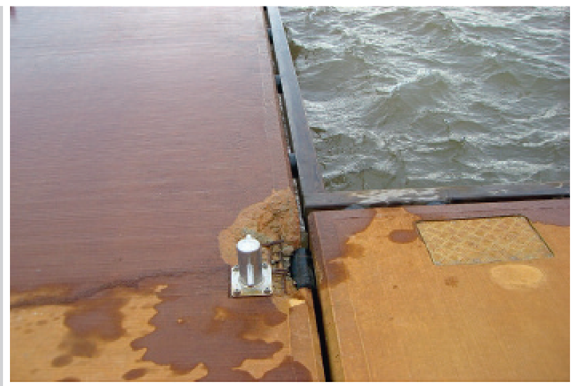

Figure 27.
Concrete corrosion at the floating bridge of the floating house acc. to Fig. 17, 28

4.3.1. Reinforced concrete pontoon

Fig. 14 shows the attacks of wind-waves on a floating house located on a post-mining lake flooded with water almost completely.

Figure 28.
Waves at the lake "Partwitzer See"– a former opencast lignite mine in the Lusatian Lakeland

For prediction of wave heights we need a method to predict the wave action. Fig. 29 shows preparation for installing a buoy to measure wave heights und frequencies using GPS method (global positioning system).

Figure 29.
For installing of the measuring buoy in the lake of a former opencast lignite mine a long and heavy anchor chain is necessary

Yet the dynamic loading of concrete is not the only reason for the damage. Above all things a low level of the ph-value causes a strong corrosion (see Figure 27). Investigations for new concrete formulations and innovative composition of concrete are underway.

Figure 30.
Investigation of concrete samples subjected to different areas: water, air and fluctuating zone between water and air

Figure 31.
Samples with different concrete mix design, collected by means of a special removing assistance after a water load of one years in the lake of Partwitz

For investigation the samples are divided to the 4 zones:

A: area is entirely above the level of water
B: area is located fluctuating between water and air
C/D: area is completely submerged in the water

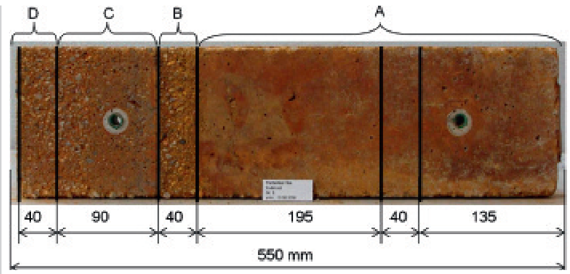

Figure 32.
The sketch of the figure gives the names and dimensions of the areas of a concrete sample

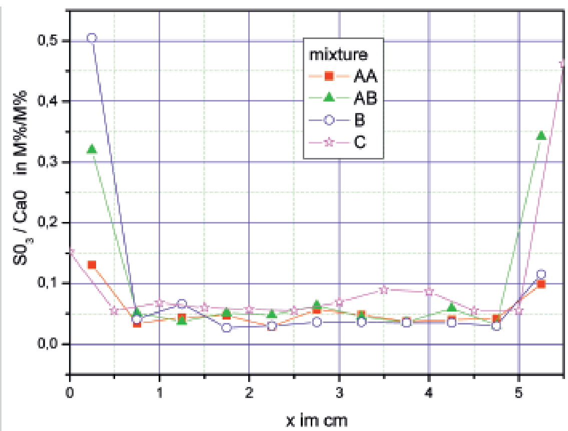

Figure 33.
The graph shows distribution of chemically bound sulfur after a load of one year in the water of the lake Partwitz

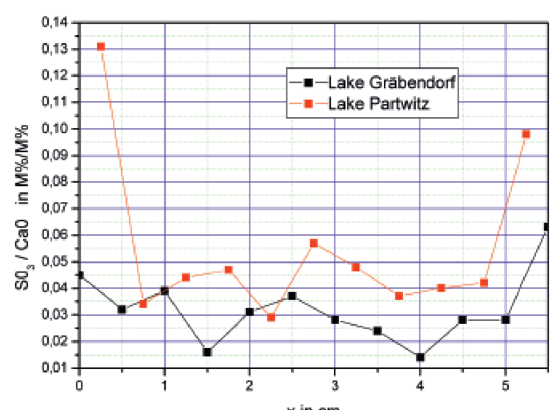

Figure 34.
The graph shows a comparison of the results concerning the distribution of sulfur in the area A between the samples loaded one year in the water of the lakes Partwitz and Gräbendorf

4.3.2. Steel pontoon

Steel pontoons must be overcoated with an additional surfacing of high quality. Of course this is necessary if it is planned to put the pontoons into post-mining lakes with a ph-value measured according to Figure 36.

Figure 35.
Result of a PUR coated steel plate after it had been exposed to an attack of the water in the lake Partwitz of a former opencast lignite mine for two years

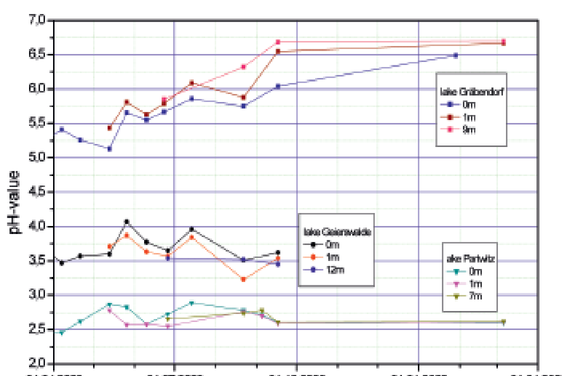

Figure 36.
Course of the ph-value of different lakes in the Lusatian Lakeland

4.4. Algue determination

The microbiological growth of surfaces is a topic worldwide ([5], Stopp & Strangfeld, 2003), ([6], Stopp & Strangfeld, 2004). Owing to the improved thermal insulation of envelope parts of buildings the external surfaces tend to a natural state. Currently and in the context with the investigation of floating houses by the authors the systematic measurements of algues are underway.

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