

**REUSING WATER TREATMENT PLANT SLUDGE AS SECONDARY RAW MATERIAL IN
BRICK MANUFACTURING**

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ABSTRACT

In conjunction with Boral and TNO Environment, Energy and Process innovation, Reststoffenunie has manufactured on an industrial scale a trial production run of bricks (70,000) from clay to which drinking-water sludge was added. The bricks were assessed in terms of production technique and environmental impact (leaching behaviour). The results of the study were then taken as a basis for closer evaluation of the feasibility of this option. The Dutch government is fostering the useful application of waste substances and therefore part financed the project (DROP subsidy scheme from the Department of Public Works/Road and Hydraulic Engineering Division and the ministry of Housing, Spatial Planning and the Environment).

The study showed that water iron is ideally suited as a red-colouring agent in brick production. From the process technique point of view, water iron is relatively simple to incorporate. In terms of leaching behaviour, the bricks satisfy the requirements of the Building Materials Decree and this application is economically attractive both to the water companies and the brick industry. The process has now become reality. Reststoffenunie has signed a 5-year contract with Boral Industrie B.V. on the basis of these study results.

Outline of the problems/introduction

Drinking-water sludge that is rich in iron (also referred to as water iron) is produced at dozens of drinking-water sites in the Netherlands. Until recently, the bulk of the sludge produced was stored in what are termed flushing ponds. A large amount of historical production is still stored in these basins. Reststoffenunie (Residual Substances Union) was set up in 1995 for the purpose of processing the residual substances released in an environmentally acceptable manner and at a reasonable price. A market survey revealed that the brick industry would be an interesting option for drinking-water sludge in terms of quality and quantity alike. The iron component could be used as a red-colouring agent and the other anorganic components to replace primary raw materials.

Trial brick production

After positive results had been achieved on a small scale in using iron-rich drinking water sludge, a trial brick-production run was organized to investigate whether the use of water iron was actually feasible technically and environmentally, would lead to a saleable product and would provide a use for water iron that was satisfactory to all parties. The trial was carried out with ten tons of water iron that could be regarded as representative of national water-iron production in terms of composition. The water iron had been dried in a sludge depot to around 50% dry matter and contained 35% Fe and 150 ppm arsenic. A 5% injection by volume was taken as the dosage (3% dosage based on dry matter). Experience had already been gained with this dosage in the preliminary investigation. The addition of this quantity raised the iron-lime from 0.85 to 1.05. This ratio is decisive for the colour of the brick.

Mixing water iron with clay was performed in a similar way to mixing various clays. This means that the water iron in the raw-materials depot at the brick factory was added to the clay. The manufacturing process did not require any modifications. The trial set-up was selected to produce bricks over a few hours. A total of some 70,000 bricks were produced over this period.

The trial revealed that using water iron had a positive effect on drying properties. There was less breakage through drying than was customary and shrinkage through drying was also slightly less. Inspection of the product indicated that a better red colouring had been achieved. One negative aspect to emerge was that compression strength had declined slightly. The reason lay in the water iron producing a leaner mix. It is anticipated that minor adjustments to the process can modify the negative impact on compression strength. That said, the bricks did still comply with the statutory requirement for compression strength.

Effect on composition of raw materials and emissions

A comparison of the macro- and micro-components of water iron and types of clay used in the Netherlands revealed that on average it was only the Fe, Mn, As, Zn, Cu and chloride levels in water iron that were clearly higher than in clay. As far as the other components are concerned, the levels in water iron were the same or

lower than the levels in the clays. The effect of adding the water iron on the composition of the raw material was minimal at a dosage of 5 vol-% with the exception of the iron and manganese content. The iron content rises from 4.0 to 5.8% (a 45% increase) and the manganese content from 0.08% to 0.13% (a 60% increase). Such a rise in the manganese level is not a problem. It will come as no surprise to learn therefore that such dosages have little impact on the expected emissions to air.

Impact on composition of raw materials and emissions to air

Component	Change in input composition	Effect on emission
As	rise in concentration from 12 to around 15 mg/kg	Zero
Fe ₂ O ₃	rise in level from 4 to 5,8%	Zero
CaO	no change in 3.2% level	
MnO	rise in level from 0.08 to 0.13%	Zero
Cu	rise in concentration from 13 to around 16 mg/kg	Zero
Zn	rise in concentration from 67 to 70 mg/kg	Zero
Other heavy metals	slight rise in concentration	Zero
Halogens (F, Cl, Br)	minor change in concentration	Zero
Organic substances content	decline in level from 6.3 to 6.2%	Zero

Leaching trial

Leaching trials revealed that the availability for leaching of the components from the water iron being studied was at the detection boundary of the analysis method. The availability from water iron was comparable with that from clay and if anything was less and not more available for leaching. It was established for As, Cr, V, F and S components that the baking process increases availability. A point to note is that this is not a consequence of the addition of water iron but of compounds (such as arsenates, chromates and vanadates) formed through oxidation during the baking process, which are better soluble and better available for leaching than the compounds of these components that occur in clays. As far as most of the other main elements are concerned, the availability for leaching declines as a result of the sintering of the product during the baking process.

It is true of all the components investigated that leaching from the brick by the addition of water iron leads to immissions that are lower than the maximum permissible (mpi) for a category 1A application in the Building Materials Decree. Of the components investigated, As (0.5 times mpi), V (0.4 times mpi) and F (0.2 times mpi) were the most critical. These immissions are comparable with those of bricks without the addition of water iron. No impact on immission to soil was therefore identified from using water iron.

The leaching to soil from a broken brick was also lower than the mpi for category 1 and 2 applications. This means that the broken brick can be used at a second phase of its life as a non-moulded construction material in a category 1 application.

Immissions calculated with standard use of building bricks with and without water iron.

Elements	Immission (mg/m ²)			mpi (mg/m ²)
	13 building bricks without water iron	red Rhine/Waal clay brick	building brick with water iron	
As	4-213	50	75	435
F	664-2258	1627	1,100	14,000
V	39-697	266	280	2400
Mo	15-169	-	11	150

Evaluation/use in practice

Given the positive experiences of the trial production, this use of sludge has meanwhile been implemented in practice. One major boost here is that the Ministry of Housing, Spatial Planning and the Environment has issued what is termed a declaration of non-applicability. Water iron can be regarded as a full raw material in its own right. The negative label of waste substance is no longer

applicable.

There is no problem in terms of sales volume, as the total quantity of water iron that can be used in brick production exceeds several-fold the total annual production of water iron of around 20,000 ton (dry matter).

The water companies and the brick industry will have to take a number of measures in using water iron. For example, the brick industry will have to create a supply of water iron in a depot, because the supply of water iron does not match demand as a result of seasonal factors and other influences. No additional measures need be taken for this storage. Studies by the KIWA revealed that the leaching of water iron satisfies category 1 requirements under the Building\ Materials Decree.

To ensure consistency of input quality, the various consignments of water iron in the depot should be mixed into a homogenous whole prior to use. As the water iron originates from various water supply sites, the water companies are considering setting up a certification system. The certification process will lay down requirements for the macro composition (moisture content, sand percentage, iron and manganese content, organic substances, etc.) and the micro composition (including the arsenic content). The sludge treatment (thickening and dewatering) will also have to be optimised.

An economic analysis has shown that the costs of the brick option (including dewatering) are lower by a factor of 2 than the treatment costs with other options such as use as a flocculation agent for dewatering sewage sludge or use as a dephosphating agent.

Usage as a raw material for the brick industry is attractive to the water companies (saving on dumping costs) and the brick industry (saving on the cost of raw materials) alike. This is therefore a win-win situation.

Meanwhile all the water companies have confirmed that they regard this as the most attractive option for the medium and long term.