



Characterisation of Mineral Wastes, Resources and Processing technologies – Integrated waste management for the production of construction material

WRT 177 / WR0115

Case Study:

Water treatment residues as a clay replacement and colorant in facing bricks

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Introduction

Water treatment residues (WTR) are sludge cake materials generated from the latter stages of the treatment of water destined for drinking to make it wholesome and safe to drink. This treatment is conducted in purification plants (water treatment works). The treatment process is required to help fine particles to stick to each other to produce a floc. The floc forms a sludge which is then de-watered. The quantity of WTR produced in the UK is estimated to be 131,000 (dry) tonnes per annum with 87 % being landfilled or discharged back into the water treatment works. A high proportion of the remaining 13% of WTR is used in landspreading applications (1).



Figure 1: Aluminium-based drinking water treatment residue www.ars.usda.gov

Potential construction applications for water treatment residues

WTR may be used in ceramic products as a clay substitute or colorant, (in principal) as a source of Ca, Al, Si and Fe in Portland cement manufacture (although the moisture content is a barrier to this use) or in road making (2, 3). The use of WTR in bricks is not new and dates from 1995 in the UK. Several past trials were undertaken in the UK, where the incorporation of WTR into bricks as colorant or clay substitute was investigated (4, 5).

The composition of WTR cake differs between different sources, being either iron or aluminium rich (depending on the type of flocculent used) and it may not always serve as an appropriate alternative material for brick making. The purpose of this case study therefore is not to prove that WTR could find application in brick manufacture, but to investigate the properties and performance of WTR from a specific source in brick making. A summary of past investigations is given in Table 1.

Table 1: Previous research/trial projects on the incorporation of WTR in brick manufacture

Project title	Location	Reference
Welsh Water/Castle Brick trial	UK	5
Brick Business/United Utilities/Akristos trial	UK	6
Terranova Ecobricks trials	UK	7
Factory-scale proving trials using combined mixtures of three by-product wastes (including incinerated sewage sludge ash) in clay building bricks	UK	8

Brick manufacture

Brick manufacturing is a historic industry and the production process is well established. Brickworks commonly operate in close proximity to clay quarries, owned by the same company to satisfy their needs for raw materials. The market for bricks has been presented with significant changes with the introduction of concrete blocks as the latter replaced “common” bricks in construction. This resulted in a shift of the market towards producing facing bricks, used for aesthetic purposes.

The use of ‘facing bricks’, accounts for over 90% of demand and the production of facing bricks appears quite stable for the last seven years (9). Bricks are produced either by extrusion or by the ‘soft-mud’ process, but extrusion comprises the most common option (Figure 2). Bricks are dried prior to firing in a linear kiln (tunnel kiln), which commonly operates on natural gas.

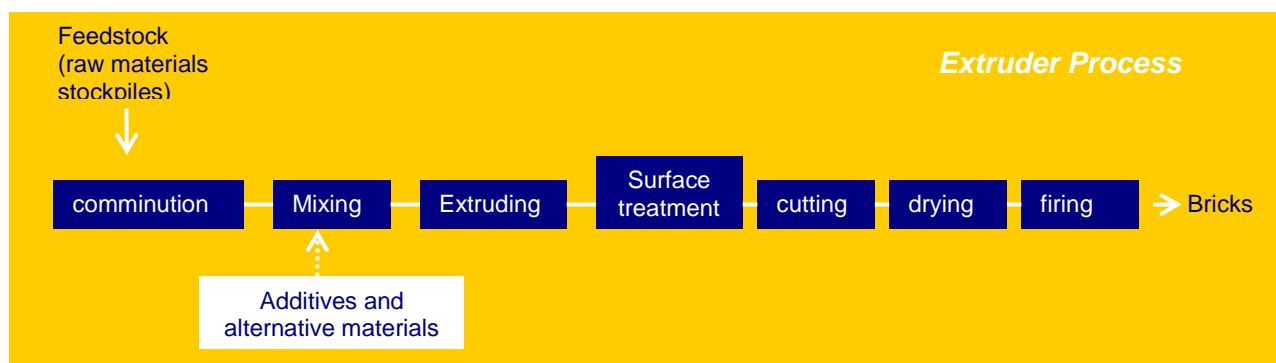


Figure 2: Brick manufacture – The extrusion process

Alternative materials are considered for use by brick manufacture as a potential cost effective solution to access materials with desirable compounds/ properties that will satisfy the demand for large portfolios of products with different aesthetic properties. The sector’s view is that customer demand and expectations have changed significantly and a market for ‘green products’ is currently present.

Water treatment residues are most commonly used as a colorant or clay replacement. From interviews, the project team found that trials have been undertaken by brick manufacturers and the major constraint regarding their use was the high moisture content of the WTR. In comparison to dry alternative materials, water treatment residues will be introduced in later stages into the making process, namely double shaft mixer.

Barriers and Benefits (extracted from waste product pairing database)

The Waste-Product Pairings (WPP) database includes information relevant to the benefits, obstacles and analysis required for determining the potential for wastes to be utilised by the brick manufacture. This information, for WTR is shown below:

1. Contribution to the end product. WTR is used primarily as a colorant and secondarily as a clay substitute. In the case described, its primary use is as a clay replacement. Trials with iron-rich sludge showed an enhancement in the colour of red bricks.
2. Potential benefits:
 - Material related:
 - i. Improves plasticity
 - ii. Certain aluminium-rich WTR can act as a fluxing agent to lower firing temperature without affecting the end product properties (not true of this particular waste source).
 - Environmental – Organisational - Social:
 - i. Conservation of resources of virgin materials
 - ii. Emission reduction and less energy requirements (due to the fluxing properties- in the case of aluminium-rich WTR)
 - iii. Production of products with recycled content
 - iv. Achieving brick sector sustainability objectives by minimising the use of primary resources. If only 5% of the clay raw materials used to make bricks were to be substituted by alternative raw materials, this would create a market for over 400,000 tonnes of waste.
 - Economic:
 - i. Reduced energy cost due to the fluxing properties (for aluminium-rich WTR).
 - ii. Gate fee (benefit to brick producer)
3. Potential barriers:
 - Material related:
 - i. The composition of WTR varies substantially depending on the type of flocculent used.
 - ii. There may be difficulty in introducing a very wet material into a relatively dry brick making feedstock.
 - iii. Appearance of trial bricks is poorer than that of the control bricks.
 - Economic
 - i. Additional storage infrastructure will require company's investment.
 - ii. Processing cost.
 - iii. Low landfill cost discourages exploration for alternatives to disposal.
 - Social
 - i. Possible poor public perception of the use of WRT due to a potential to confuse with sewage sludge.

The brickworks does not require a waste management licence to use WTR in their process. The WTR is supplied as a product to meet a defined specification (see below).

4. Analysis requirements for WTR:

Testing is carried out to identify the properties and characteristics of alternative materials and end products, as well as to determine that the inclusion of certain alternative materials provide desirable results during lab-based experimentation.

Analysis on alternative materials:

mineralogy; chemical (oxide) analysis; particle size analysis; bulk density

Analysis during lab-based experimentation:

appearance of test bricks after firing; shrinkage; experimentation with different substitution rates; decision upon the type of clay body suitable for use with WTR; firing temperature

Analysis on end products:

in accordance with BS EN 771-1 on masonry products; colour; durability; green strength; water absorption; efflorescence; compression strength

The WTR is supplied to meet a specification including chemical analysis, ceramic property assessment, carbon/sulphur testing, loss-on-ignition, fired colour, etc.

WTR samples

Samples of WTR were acquired from the Wybersley Water Treatment Works of United Utilities located off the A6 Manchester to Buxton Road. The site produces approx. 2,500 to 3,000 tonnes per year of the WTR material. The plant provides the process stages seen in Figure 3.

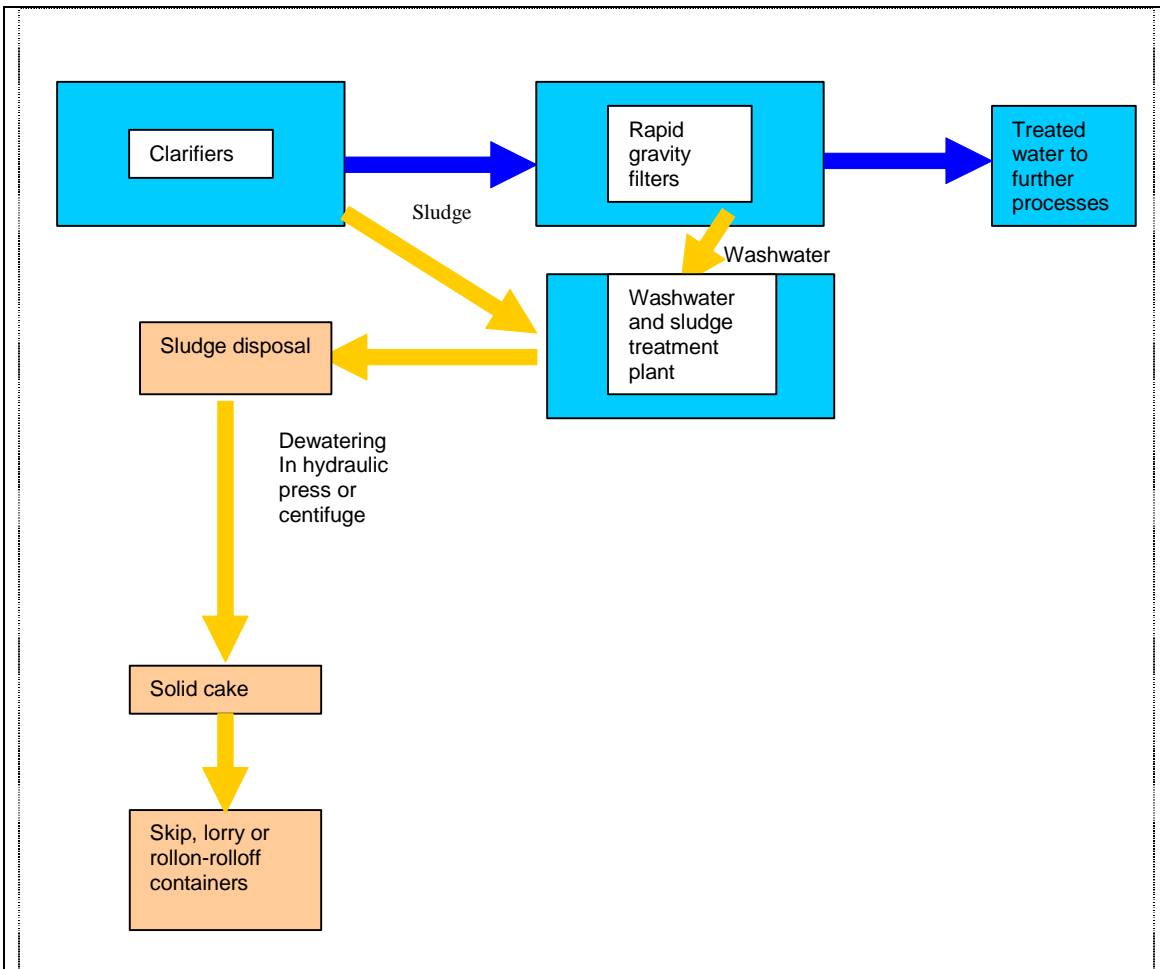


Figure 3: Water Treatment – process stages.

The WTR is pre-mixed with Shale materials and then further bucket mixed prior to introduction via a box feeder into the works.

WTR characterisation results

There are limited data available on the WTR used in this case. Available information (derived from reference 1), is presented in Table 2.

Table 2: WTR characterisation results.

WTR	
Visual description	Reddish brown crushed filter cake, lumps to fine powder
Mineralogy	Iron sulphate
Total oxide analysis (pre-calcined)	SiO ₂ ; 27.60, TiO ₂ ; 0.0, Al ₂ O ₃ ; 6.50, Fe ₂ O ₃ ; 26.40, MnO ₂ ; 5.62, CaO; 33.06, MgO; 0.53, K ₂ O; 0.33
Particle size distribution	Fine material, forming coagulated lumps.
Particle density	n/a
Water absorption	n/a
Acid soluble chloride (%)	n/a
Total sulphur (%)	0
Moisture content (%)	Approx. 80% (of wet weight) after filter pressing
Loss on ignition (%)	76.43

Results of Laboratory / Pilot product demonstration test-work

The use of WTR in bricks was investigated on a laboratory scale by Akristos, before proceeding with works trials at Wienerberger Limited at Denton, Manchester (6, 7). The objective of these experiments was to identify whether the specific material could be incorporated into bricks primarily as a clay substitute and to examine if changes in the colour and face appearance of the bricks occur.

Results from laboratory trials demonstrated that WTR could be used as a colorant and partial clay replacement in bricks. It was found that the water absorption was similar in the test and the control brick samples. Also during the drying process additional energy consumption may occur. This is seen as a substantial economic and environmental barrier. Finally, the WTR from Wybersley did not illustrate any fluxing properties. Experimentation with different clay bodies and/or aluminium based WTR's may, however, give different results (7). The bricks produced all passed the British Standard tests including compressive strength, water absorption and durability.

Large-scale production runs were then undertaken incorporating up to 5% WTR in the raw material blend. WTR materials have now been accepted by Wienerberger as clay ARM's. Full scale use of WTR's within the brick-clay blend started in Q4 of 2002.

Akristos have conducted trials with a number of ARM's to produce a range known as "Terranova Eco-bricks". These have included a range of raw materials (including WTR's) to produce bricks with 30-40% recycled materials content.

Conclusions and further work required

The use of WTR from Wybersley Works a clay substitute for bricks is technically feasible. The brick market is mainly interested in materials that can provide a range of colours, marks and textures hence visual effects. The use of alternative materials as clay substitutes are considered by the brick sector only when suitable primary sources are not found in close proximity or if the cost of secondary materials in combination with their properties is advantageous. The final decision upon the use of WTR or any other alternative material in bricks is taken after several trial stages including small scale and full scale trials. Often the cost and disturbance from production caused from industrial scale trials is considered a constraint for the brick manufacture. However, the brickworks is using the WTR as a clay replacement material and to help with the fired colour. The real drive to use such a material is:

1. Utilising a material from a sustainable source and;
2. Economic There is normally a "gate" fee associated with the material

The brickworks has not identified any additional costs associated with drying as they are adding water to the mix for extrusion.

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