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Construction aggregates for urban development: Consumption, sterilisation and the environment

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Abstract: The relationship between economic growth, urban expansion, aggregate consumption and its resultant implications with respect to the environment is depicted well in the Langat Basin, which is situated south of the Klang Valley, in the states of Selangor and Negeri Sembilan. Extensive development within the Basin has created demand for construction aggregates and brought to fore environmental problems associated with quarrying. Uncoordinated planning of land development has contributed to aggregate resource sterilization, and if left unchecked may threaten future environmental well-being of the Basin. Policy instruments using mineral landbanks for construction aggregates and buffer zones for quarry operations is an option that can be considered to address these problems.

Abstrak: Hubungkait pertumbuhan ekonomi, pengembangan kawasan bandar, penggunaan agregat dan implikasinya terhadap alam sekitar dapat digambarkan di Lembangan Langat, yang terletak di selatan Lembah Klang, di negeri Selangor dan Negeri Sembilan. Pembangunan pesat dalam Lembangan Langat telah meningkatkan permintaan untuk agregat dan menyebabkan masalah pencemaran berkaitan dengan operasi pengkuarian. Perancangan pembangunan tanah yang kurang terselaras pula telah menyumbang terhadap pembekuan sumber agregat dan justeru menggugat kesejahteraan alam sekitar Lembangan tersebut di jangka panjang. Perkara ini boleh ditangani melalui penggunaan instrumen polisi berasaskan simpanan mineral untuk sumber batuan binaan dan zon penampan bagi operasi pengkuarian.

INTRODUCTION

Rapid economic growth of the early and mid 1990's has resulted in unprecedented levels of urban expansion in many parts of Malaysia. In response to this, the quarrying industry also expanded to provide adequate construction aggregates, both in terms of production and number of operations. Aggregates and related construction materials are essential in the construction industry and public works. Adequate supply of these materials is important to support national development and ensure societal well-being, particularly with respect to provision of shelter.

The relationship between economic growth, urban expansion and intensive use of construction aggregates is depicted well in the Langat Basin. The Langat Basin is situated south and adjacent to the Klang Valley, Malaysia's highly developed urban conurbation. It has an area of about 2930 km^2 covering parts of Selangor and Negeri Sembilan. The Basin hosts the Kuala Lumpur International Airport, Putrajaya and Cyberjaya. These development projects have spurred an influx of commerce and industry into the Basin. As a result, there has been rapid expansion of housing settlements, industrial estates and business centres.

This paper traces the history of aggregate consumption in the Langat Basin in the context of its sustainability, particularly with respect to the environment. Extensive development within the Basin created demand for construction aggregates, and this in turn brought to fore environmental problems associated with quarrying. Uncoordinated planning of land development subsequently restricted the availability of aggregates. This situation threatens future environmental well-being of the Basin because the best areas for aggregate resources are presently locked under forest reserves.

AGGREGATE CONSUMPTION

In Malaysia, aggregate refers to quarried rock products, which are generally extracted by drilling and blasting, followed by crushing and sizing processes to prepare the rock in a form suitable for use as construction material. The main rock types exploited as aggregate are granite and limestone (JMG, 2001). Aggregates are used primarily in the construction of major buildings and infrastructure as well as for minor industrial applications.

In the Langat Basin, only granite is exploited as aggregate. In 1999, about 20 quarries were reported to be operating in the Basin (Pereira, 2000). In terms of tonnage, almost all the aggregate extracted were consumed within the Basin. Between 1980 and 1989, the annual production rate increased by about 5% (Figure 1). Subsequently, between 1990 and 1996, the annual rate of aggregate production increased by nearly 30%. This increase coincides with the opening of the southern development corridor in the states of Selangor and Negeri Sembilan, which includes part of the Langat Basin, for development. In 1997, aggregate production dropped by about 60% compared to the previous year and has since remained at this level. This was due to the economic slowdown that affected Malaysia and other Southeast Asian economies.

The national aggregate consumption for 1995 is 4.7 tonnes/capita. This is similar to annual consumption levels in some developed countries, such as the United States (4.8 tonnes/capita; Tepordei, 1997), Canada (4.0 tonnes/capita; Lyday, 1997), Australia (3.6 tonnes/capita; Doan, 1997) and the United Kingdom (3.2 tonnes/capita; Newman, 1997). However, in the Langat Basin the consumption level was highest in 1995, nearly eight times higher than the national level, at about 37 tonnes/capita. This high level of aggregate production reflects the intense physical development in the Langat Basin, with the opening of the southern development corridor.

An analyses of aggregate flows in Selangor has revealed that aggregates used in the construction of major buildings and infrastructure are not reused or recycled but eventually ends up in open dumps, contributing to unsustainable use of this depleting resource (Wong *et al.*, 2003). Aggregate is a basic resource that is required to support physical development to ensure societal well being. The high level of aggregate consumption in the Langat Basin, coupled with its unsustainable use as revealed by the flow analyses, is very unhealthy for the long-term well-being of the Langat Basin.

STERILISATION OF AGGREGATE RESOURCES

In terms of area, about 35% of the Langat Basin has high potential for aggregate resources. The major high potential area is located in the upper eastern section of the Langat Basin, in the region of the Langat, Semenyih and Galla Forest Reserves (Pereira & Komoo, 2003). In terms of landcover, it was revealed that 15% of the high potential area has been built-up and its aggregate resources are thus, effectively sterilized. About 54% of the high potential area is under water bodies and covered by forests such as the Langat, Semenyih and Galla Forest Reserves, and the resources therein are inaccessible. Only 31% of the high potential area in the Langat Basin is available for future exploration and exploitation. All the other areas with high potential within the Basin are either sterilized or unavailable for exploration and exploitation.

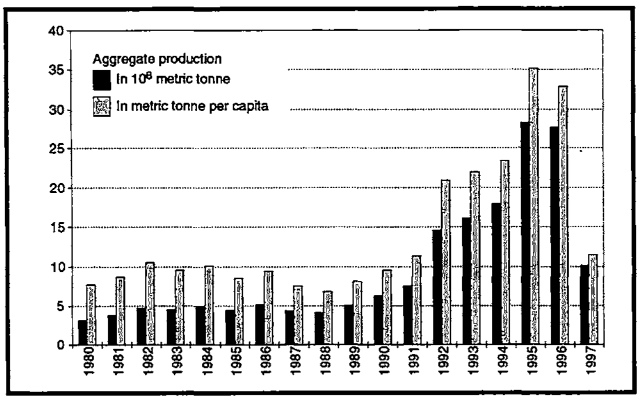

Figure 1. Production of aggregate in the Langat Basin, 1990 - 1997 (GSD, 1996, 1997, 1998).

Prior to 1981, the annual rate of aggregate sterilization by built-up areas in the Langat Basin was not significant (Table 1). The annual rate of aggregate sterilization by built-up areas between 1981 and 1998 is about 10%. Assuming that the forest cover and water bodies are retained, and the focus of development remains on the high potential areas, it is estimated that total sterilization of aggregate resources within the Langat Basin would occur within the next 15 years (Pereira & Komoo, 2003). As a result of this sterilization, the pressure to exploit high potential areas that are presently overlain by forest reserves will increase, to support development in other parts of the Basin. The removal of forest reserves in the Langat Basin for quarrying, particularly in the highlands, will adversely impact the long-term environmental well-being within the Basin.

Compounded to the sterilization of potential aggregate resources, existing quarries are increasingly being encroached by development for housing and industrial parks. This limits the expansion of such quarries to meet future demand in the Langat Basin. In addition, fly-rocks, dust pollution, vibrations and sound pollution from quarries operations endanger humans when new development projects are located near existing quarry operations.

Given this scenario, there is need to consider the establishment of mineral landbanks for aggregate resources. Mineral landbanks refer to sites with substantial reserves of specific minerals or rock materials that can be extracted for future use. With the expected urbanization and development in the Langat Basin, the requirement for aggregate is expected to increase to meet the demand of the building industry. Thus, mineral landbanks should be delineated for aggregate resources to ensure that its supply is not threatened in the future. These landbanks should be maintained for mineral development to sustain future physical development in the Langat Basin. In addition, buffer zones should also be identified around existing quarries. This is to prevent the encroachment of development that would limit the expansion of existing quarries.

The mineral landbank and buffer zone approaches for construction aggregates can be implemented through the Policy on Environmentally Sensitive Areas, as defined for

Table 1. Landuse percentage of the high potential area for aggregates which represents 35% of the Langat Basin, which has an area of 2938 km^2. The 1998 data is for land cover based on the TM Landsat image. All other data is derived from landuse maps produced by the Agriculture Department of Malaysia.

Landuse	1974	1981	1995	1998
Built-up area	3	3	13	15
Forest	53	52	50	50
Water Body	4	4	4	4
Agriculture-based	40	41	33	31
TOTAL	100	100	100	100

the State of Selangor (GoS, 1999). This policy recommends the identification of mineral landbanks and creation of buffers zones around extraction sites for strategic minerals. Given its importance for provision of shelter, construction aggregates is a strategic mineral that needs to be delineated and used in a sustainable manner for the well being of future generations.

ENVIRONMENTAL IMPACTS OF AGGREGATE EXTRACTION

Rapid growth in the last decade has resulted in the development of residential and industrial areas close to many of the quarries in the Langat Basin. Quarrying operations are often resented by the public because of the nuisance and potential health hazards in addition to damages to the environment, property, crops and livestock. The most common public complaint about quarrying operations received by the Department of Environment is air pollution, mainly in the form of dust or particulate materials which is clearly visible (Ng, 2001). Other concerns related to quarrying are visual impact; ground vibrations mainly from blasting; noise pollution due to airblast, machinery and traffic; flyrock as well as siltation and water pollution.

A 20-month dustfall monitoring program was carried out in the Nilai area in the southeastern part of the Langat Basin. During the monitoring period (October 1994 - May 1996) there were seven quarries in granitic rocks at the fringes of the Galla Forest Reserve. Dustfall level was monitored using modified ASTM dust deposit gauges in 20 sites with distances of between 100 m to 6 km from the quarries. The monthly dustfall rates ranged from 0.02 to 2.15 g/m^{2}d. Generally, the level of dustfall decreases away from the quarries (Figures 2 and 3). The mean dustfall level for the whole monitoring period for stations that are located less than 1 km from the nearest quarry is 0.33 g/m^{2}d, exceeding the DOE's recommended guideline of 0.133 g/m^{2}d (DOE, 1992). For monitoring sites between 1 and 3 km from the nearest quarry, the mean dustfall is 0.07 g/m^{2}d, while those between 3 and 6 km is 0.06 g/m^{2}d.

The principal sources of dust from quarrying operations in the Langat Basin were related to communition processes (crushing, drilling, blasting), screening, traffic movements, conveying and dumping of aggregate into the hopper and stockpiles. To minimise dust caused by drilling, dust collection and suppression systems should be installed to the rigs. Dust related to screening, crushing, conveying and dumping can be suppressed by water sprays and enclosures of the plants and stockpiles. Proper maintenance and the wetting of roads can minimise dust caused by traffic movements. Although dust can be suppressed during quarrying operations, not all operators in the Langat Basin take effective action to minimise dust emission (Ng *et al.*, 1995).

There have been incidents of water pollution caused by accidental spillage, leakage or discharge of liquid fuel and oil from machinery. Siltation is a common problem in quarries, particularly during land clearing, site preparation and the early stage of quarry operation. The silt-laden rain water run-off, discharged into nearby streams, cause an increase in the concentration of suspended solids and turbidity of the stream water. This deteriorates the water quality, making the water unfit or less suitable for human use and aquatic life.

Noise is often considered a nuisance to the public, and may cause permanent or temporary hearing impairment to quarry workers. The main sources of noise are from traffic movements, processing equipment, drilling and blasting. Presently, there is no enforced regulation on the level of noise generated in quarries that affect the public, although the noise level the quarry workers are exposed to is governed by the Factories and Machinery (Noise Exposure) Regulation, 1989. None of the quarries in the area construct any sound barriers around the perimeter of the operations.

Complaints of damage and nuisance due to blasting are common whenever a quarry is located close to populated

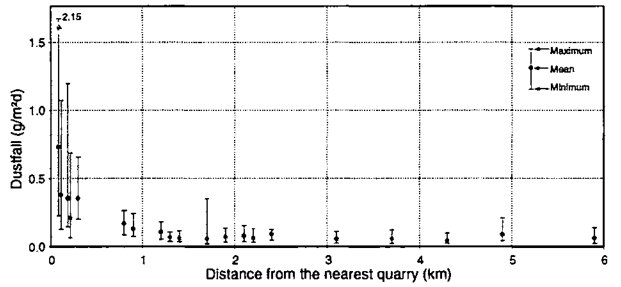

Figure 2. Plot of dustfall against the distance of the monitoring sites from the nearest quarry between October 1994 to May 1996.

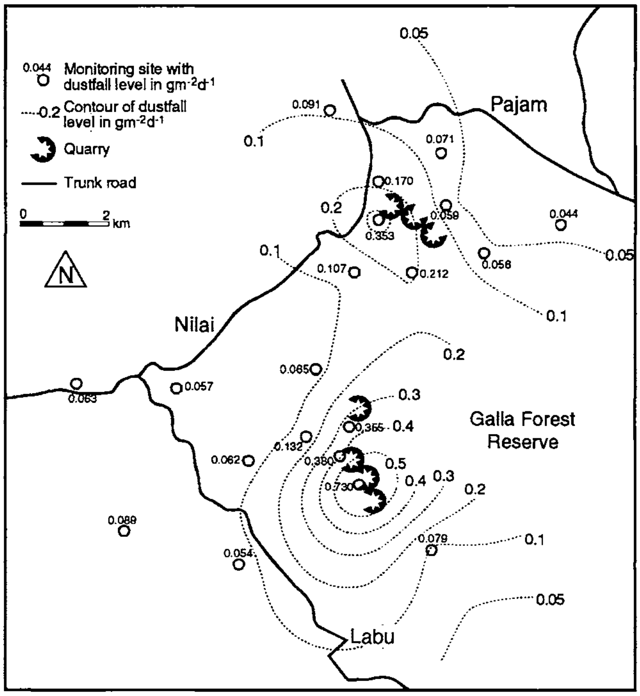

Figure 3. Mean dustfall level in the Nilai area between October 1994 and May 1996.

areas. The main problems related to blasting are ground vibration, air blast and the occurrence of flyrock. All three have damaging effects on building, and the later pose a safety hazard. Although uncommon, there have been reports of damages to buildings, injuries and death.

Almost all the aggregates in the Langat Basin is delivered to the point of use by trucks, which have become a source of nuisance and a safety hazard. The main impacts of the truck traffic are public safety, noise and vibration, air pollution and the interference of these trucks with private traffic. Other reported problems related to quarry operations include mudflow during or after heavy rainfall caused by improper disposal of overburden on the hill slopes.

Quarrying is only a temporary use of land, and quarry operators are obliged to reclaim the working sites upon exhaustion of the rock material to a condition suitable for some use. However, most quarry operators pay little attention to rehabilitation and reclamation.

CONCLUSION

Aggregate consumption in the Langat Basin has been increasing over the past two decades. The highest consumption level was in 1995, nearly eight times higher than the national level, at about 37 tonnes/capita, during a period of rapid economic growth. This consumption level is not sustainable given the prevalence of aggregate waste disposal without consideration for reuse or recycling. Compounded to this, certain environmental impacts associated with quarrying have been inadequately addressed. For example, dust pollution exceeds recommended guidelines, in areas located less than 1 km from the quarry. In addition, the high rate of aggregate resource sterilisation also threatens the future environmental well-being of the Langat Basin. This is because the best areas for aggregate resources are presently locked under forest reserves, and these may be exploited in the next 15 years, if the present rates of sterilisation continues. Policy instruments using mineral landbanks for construction aggregates and buffer zones for quarry operations is an option that can be considered to address these problems.

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