Dr. U. Tränkle, AG.L.N. Blaubeuren, Blaubeuren, Dr. M. Rademacher, Dr. G. Friedel, HeidelbergCement Technology Center, Leimen, R. Löckener, Sustain Consult, Dortmund, M. Basten, V. Schmid, Bundesverband der Deutschen Zementindustrie, Berlin, Germany

SUMMARY

The pilot project „Sustainable development indicators for integrated raw material and nature conservation management" – an important constituent of the initiative for sustainability in the German cement industry – was completed after a duration of two and a half years. The research project provided scientifically based solutions for further optimization of the balance between raw material extraction and nature conservation. In the debate about sustainable development an increasingly important part is played by innovative approaches for securing biodiversity not only in Germany but also internationally. Certainly, the extraction of raw materials for cement production represents a substantial intervention in nature and the landscape. However, even while they are in operation quarries can also take on an important function in the protection of nature and species: with their specific site conditions they often provide a habitat for rare and endangered spieces of animals and plants that hardly exist any more in cultivated landscapes. The aim of the pilot project was to develop indicators with which it is possible to measure the diversity of species and habitats in quarries. Different indicators for flora, fauna and types of habitat that were tailored to suit the specific conditions and potential of mining areas were developed during the project so that equal justice could be done to the demands of quarry operation and of nature conservation. The biodiversity indicators were tested during the course of the project in the quarry of HeidelbergCement AG's Schelklingen cement works as were various procedures for monitoring the diversity of species and habitats. The findings obtained were used as the basis for developing Biodiversity Action Plans that covered the specific measures for maintaining and promoting the diversity of species. The results of the project were discussed on a workshop with experts from companies and federations of different non-metallic minerals industries and on a stakeholder dialogue including authorities and NGO's.

ZUSAMMENFASSUNG

Das Pilotprojekt „Nachhaltigkeitsindikatoren für ein integriertes Rohstoff- und Naturschutzmanagement" in Schelklingen – ein wichtiger Bestandteil der Initiative für Nachhaltigkeit in der deutschen Zementindustrie – wurde nach zweieinhalbjähriger Laufzeit abgeschlossen. Das Forschungsvorhaben liefert wissenschaftlich fundierte Lösungen zur weiteren Optimierung des Ausgleichs von Rohstoffgewinnung und Naturschutz. Im Rahmen der Diskussion um eine nachhaltige Entwicklung spielen innovative Ansätze zur Sicherung der Biodiversität nicht nur in Deutschland, sondern auch international eine zunehmend wichtige Rolle. Zwar stellt der Abbau von Rohstoffen für die Zementproduktion einen erheblichen Eingriff in Natur und Landschaft dar. Gleichzeitig können Steinbrüche aber bereits während des Betriebes eine wichtige Funktion für den Natur- und Artenschutz übernehmen: Mit ihren spezifischen Standortbedingungen bieten sie oftmals einen Lebensraum für seltene und gefährdete Tier- und Pflanzenarten, die in der Kulturlandschaft kaum noch zu finden sind. Ziel des Pilotprojekts war es, Indikatoren zu entwickeln, mit denen die Arten- und Lebensraumvielfalt von Steinbrüchen messbar gemacht werden kann. Im Projekt wurden verschiedene Indikatoren für Flora, Fauna und Lebensraumtypen entwickelt, die auf die spezifischen Verhältnisse und Potenziale von Abbaustätten zugeschnitten sind, um den Anforderungen der betrieblichen Praxis im Steinbruchbetrieb und des Naturschutzes gleichermaßen gerecht zu werden. Die Biodiversitätsindikatoren wurden im Zuge des Projektes im Steinbruch des Zementwerkes Schelklingen der HeidelbergCement AG ebenso getestet wie unterschiedliche Verfahren zur Erhebung der Arten- und Lebensraumvielfalt (Monitoring). Auf Basis der so gewonnenen Erkenntnisse wurden so genannte Biodiversity Action Plans entwickelt, die gezielte Maßnahmen zum Erhalt und zur Förderung der Artenvielfalt umfassen. Die Projektergebnisse wurden auf einem Workshop mit Experten aus Unternehmen und Verbänden verschiedener Steine- und Erdenindustrien sowie auf einem Stakeholder-Dialog mit Vertretern von Fachbehörden und NGO's diskutiert.

(English text supplied by the authors)

Sustainability indicators for integrated management of raw material and nature conservation – pilot project in the Schelklingen cement plant

Nachhaltigkeitsindikatoren für ein integriertes Rohstoff- und Naturschutzmanagement – Pilotprojekt im Zementwerk Schelklingen

1 Introduction

1.1 The preservation of biodiversity as a central objective in sustainable development

The environmental and socio-political discussion is increasingly following the model of sustainable development. This means a development that is equally environmentally compatible, economically stable and socially balanced and meets the requirements of the present generation without endangering the opportunities of future generations. Area protection and biodiversity have increasingly been taking on greater significance in the European Union in recent years with regard to ecological sustainability. The background is the progressive loss of habitats and species both within the European Union and globally; mainly caused by the intensive use of the natural environment by humans. The network of ecological interactions is being heavily burdened by the constriction and fragmentation of habitats and ecosystems [1]. The loss of migratory pathways and the resulting isolation of habitats lead to uncontrollable genetic changes (e.g. genetic drift), genetic impoverishment of populations and a collapse in the structures of the metapopulation. The magnitude of these problems is, for example, reflected in the inquiries by the European Environment Agency [2], in which Germany received third-last place in Europe based on the "average size of non-fragmented land parcels".

As a result of several conferences (e.g. European Union Spring Council 2001; World Summit for Sustainable Development 2002; Malahide Conference 2004, etc.), the Member States of the European Union decided to stop the decrease in biodiversity by 2010. The German efforts are concentrated in the National Sustainability Strategy, the key indicator system (KIS) of the German Federal Environment Agency, the Länder Initiative for a Set of Core Indicators (LIKI) and the National Strategy for Biological Diversity. This background is to be used to establish a system of biodiversity indicators in Europe, with which biodiversity can be measured and stabilization sanctions, as well as the promotion of biodiversity, can be managed.

1.2 Biodiversity and development of the cement industry

The protection and development of biodiversity is important for all fields of industry that require substantial areas of landscape. The cement industry is one of them: the value chain of cementitious building materials starts with raw material extraction, as the production of 1 t of cement clinker – the burned semi-manufactured product – requires approximately 1.6 t of limestone and clay. This is of great importance for sustainable development as the capital-intensive, investment security-dependent cement industry requires access to raw mineral materials in the long term.

Natural resources are increasingly being replaced by secondary input materials in cement production, and material extraction has steadily become environmentally compatible through improvements in quarry planning and quarrying technology. Nevertheless, there is further potential for optimizing raw material extraction and nature conservation. Employers and employees in the German cement industry are being involved, in cooperation with other stakeholders, e.g. voluntary nature conservation groups, in order to make use of the existing options. The relationship between raw material extraction, investment activity and nature protection is a typical example of a field in which different interests can be effectively coordinated [3].

Raw material extraction is associated with substantial intervention in nature and landscape. However, the area that is needed is only used temporarily and raw material extraction can be fitted into proper regional development strategies. A three-part project based on this background and completed at the beginning of 2003 dealt with the link between extraction of cement raw materials and nature conservation [4-6]. The results show that nowadays raw material extraction and nature conservation are not necessarily opposed to one another – more than 50 % of the former mining area has now been converted to a nature conservation area. Even active quarries can also play an important role for nature conservation. High-quality habitats, especially in regard to endangered species that are rarely found in the surrounding cultivated landscape, may develop in succession zones, which move within the quarry during the mining process. Quarries can therefore play a crucial role in the preservation of biodiversity [7-9].

However, there is a lack of suitable and generally accepted instruments that can be utilized to measure the value of nature conservation in quarries in a comprehensible way and that can be adapted to suit the European and German systems of biodiversity indicators. The available approaches for indicators do not at present consider the diversity of species and structures of active quarries. They are also unsuitable with regard to their specific conditions and potentials [10-12] or else they are only technically oriented [13].

2 The project's objectives and strategies

The initiative for sustainability in the German cement industry – collectively supported by the Socio-political Working Group of the German Cement Industry (SPADZ), the Federal German Association of the Cement Industry (BDZ), the German Cement Works Association (VDZ), and the Trade Union for Building-Agriculture-Environment (IG BAU) and the Trade Union for Mining, Chemical, Energy (IG BCE) – is concerned with this problem. In the project that is presented here, "Sustainability indicators for integrated management of raw material and nature conservation – pilot project in the Schelklingen cement plant", the initiative, together with supporters of the project would like to tackle the development of sustainability instruments with a specific view

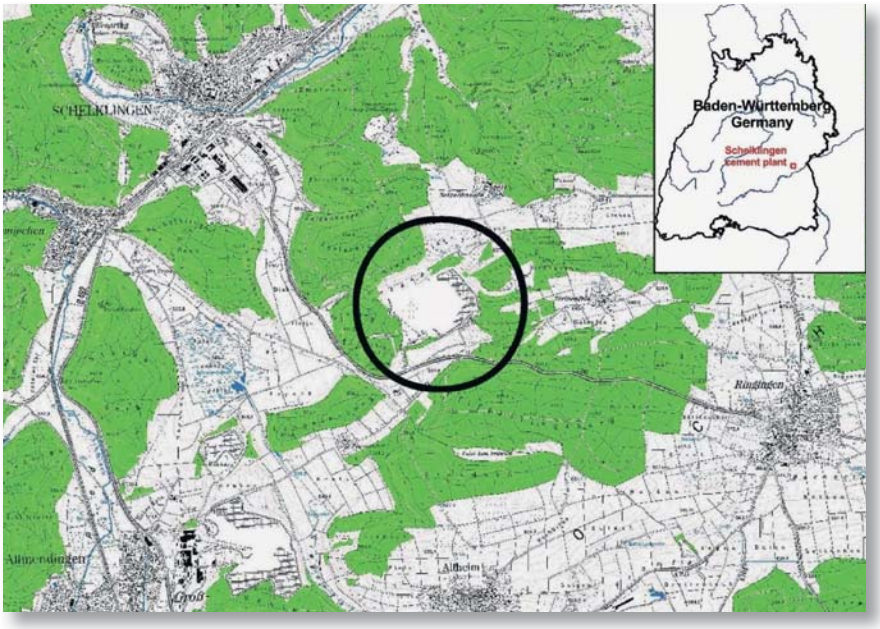

Figure 1: Investigation area at the Vohenbronnen quarry of the Schelklingen Cement Plant

towards biodiversity and the improvement of harmonization of material extraction and nature conservation.

The aim of the project is to optimize the balance of raw material extraction and nature conservation. Indicators for the qualitative and quantitative measurements of biodiversity were therefore developed and tested. This has been done in order to make it possible to measure both the nature conservation value of excavation sites, and the effects of nature conservation measures before, during and after mining. The indicators were then integrated into a Biodiversity Action Plan and a Species Action Plan; these integrate deficit analysis, research, monitoring and sanction planning – including cost estimates – and thereby support the potential and objectives of existing planning instruments and especially their ecological content.

A fundamental element of the project is adapting the indicators to the specific conditions and potential of excavation sites, so that there is a balance between the requirements of practical quarry operation and nature conservation. This also required the development of a monitoring programme that could be enforced during the mining process. An important aspect regarding the "suitability for daily use" was the transferability to other cement industry locations, as well as to other non-metallic minerals industries that were to be examined in the course of the project. Finally, the intention was to test the indicators for potential interfaces with impact regulations under nature conservation laws and with eco accounts.

The Vohenbronnen quarry – including its immediate surroundings – at the Schelklingen cement plant of HeidelbergCement AG was chosen as an investigation area for implementation of the model project (◗ Fig. 1).

This excavation site was particularly suitable because the results from the collection of data in 1993 were already available. These results could be consulted for reference values during the testing of the project's indicators. They could also be used as the basis for reference material for the advancement of eco accounts during the mining of raw material.

The project was carried out from July 2005 to December 2007 with support by the German Federal Ministry for Education and Research (promotion code: 01 LM 0401). Technical support was carried out by an advisory board during the entire course of the project in which representatives from authorities, science, industry, unions and nature conservation federations were involved. A workshop was also held with experts from companies and federations of different non-metallic minerals industries in order to discuss the results and examine their transferability. In addition a stakeholder dialogue including authorities and NGO's was held.

3 Outcomes of the project

3.1 Biotopes, flora and fauna

Detailed stocktaking of nature and landscape via several theses and independent investigations was carried out in 2006 and 2007 as part the model project. Extensive data were collected in relation to biotopes, flora, birds, amphibians, dragonflies and butterflies. This stocktaking took place both within the excavation site (area of 100.9 ha) and in a surrounding area of 500 m, starting from the edge of the quarry (area of 324.5 ha) (◗ Fig. 2). A comparison was made with the data collected in 1993 for the biotopes and flora. Abiotic location factors were also recorded within the quarry, and the creation and applicability of GIS-based habitat aptitude maps was discussed. Furthermore, existing nature

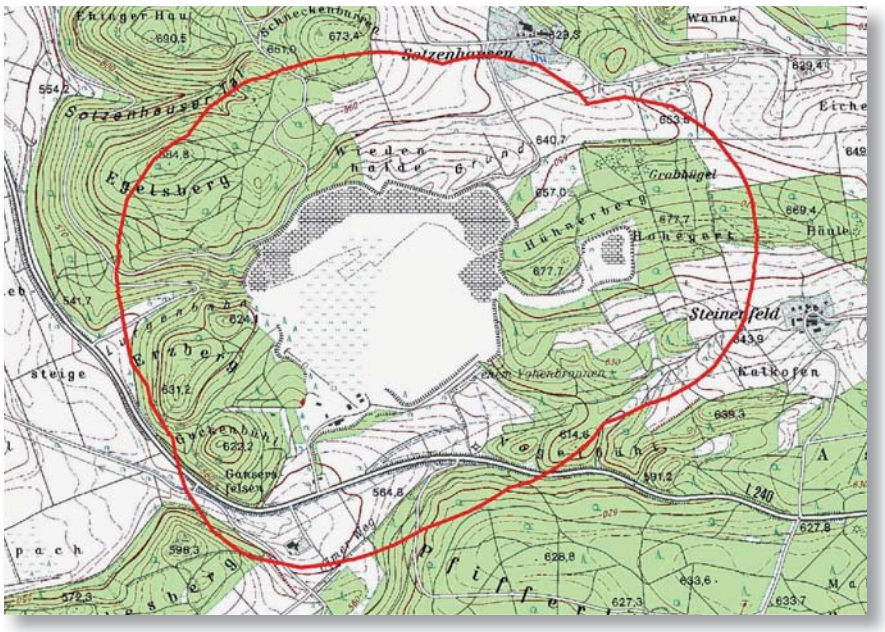

Figure 2: Investigation area for the collection of biotopes, flora and fauna

reserves and superordinate plans as well as the historical landscape development were analysed for a wide section of the landscape.

380 plant species were accounted for in the quarry in 1993, and 433 plant species in the surrounding area. 368 plant species were accounted for in the quarry in 2006, and 444 plant species in the surrounding area. This means that the quarry despite the smaller area contained 87.8 % and 82.9 %, respectively, of the number of species in the surrounding area. The number of endangered species was twelve in 1993 and eleven in 2006, while 28 and 27 endangered species, respectively, were accounted for in the surrounding area.

Altogether, 67 bird species were observed in the quarry and its surrounding area. A total of 55 bird species were found in the quarry: 43 species of breeding birds, 15 nourishment visitors and six migrants. 60 species were accounted for in the surrounding field, including 38 breeding birds, 24 feeding visitors and two migrants[*)]. The bird species of the open and semi-open cultivated landscape live predominantly in the quarry. The wheatear (two to three breeding couples) and the little ringed plover (four to five breeding couples) breed within the area of open crushed rock surfaces and screes. Altogether, 22 (33 %) of the observed bird species are endangered; five (8 %) bird species are listed in Appendix I of the Conservation of Wild Birds Directive.

In the context of the butterfly collections in 2005 and 2006, a total of 46 butterfly species were recorded in the quarry and its surrounding area. 39 species were observed in the quarry and 33 species in the surrounding area. Two species are listed as endangered in the regional red list for the Swabian highlands. Ten species appear in the early warning list. Seven of the detected species are considered endangered in the state as a whole and 14 are on the early warning list. The red list for the Federal Republic of Germany has the Melitaea didyma (red fritillary) listed as seriously endangered, and nine species as endangered. Eight species appear on the early warning list.

Nine amphibian species were accounted for; all nine species appeared in the waterbodies in the quarry and five species were found in the surrounding area. Three species are seriously endangered and three species are listed on the early warning list.

14 dragonfly species were accounted for in the investigation – eleven species in the quarry and three species in the surrounding area. Three species are endangered. The endangered dragonfly species are confined to the quarry.

The situation can be summarized by stating that despite the smaller area of the quarry when compared with the surrounding area analysed the quarry has similar figures for animal and plant species. Furthermore, the quarry reveals significantly higher numbers of endangered butterfly, amphibian and dragonfly species than the surrounding area.

3.2 Biodiversity indicators in Europe

The national and Europe-wide biodiversity indicators currently available were evaluated for integration of the set of indicators developed in the context of the model project. Special emphasis has been placed on the Europe-wide monitoring programme SEBI 2010, with a set of 26 single indicators, and on the national strategy for biological diversity in Germany with 19 single indicators. Some of the suggested indicators were adopted as a basis for the project. In particular, this covers the indicators from the section dealing with "current state and tendency of biological diversity and its properties".

3.3 Monitoring

The development of a significant and practicable monitoring programme was another central component of the pilot project. This was because only long-term application of the developed indicators will allow conclusions to be drawn about the development of the biodiversity of a surveyed area, thereby providing data-supported predictions of the development of plant and animal species. Various methods were initially considered for the implementation of the monitoring programme. Three methods were examined in greater detail and discussed during the course of the project:

- data acquisition for the complete excavation site and its surrounding area,
- data acquisition using transects (three variants) (cf. ▸ Fig. 3), and
- data acquisition over continuous areas.

The concept of continuous areas is not recommended because of the dynamics of the mining.

Evaluation of the characteristics of the transect method clearly shows that the fluctuations between the different transects can be very substantial. The statistical reliability of the method cannot be guaranteed. Moreover, various indicators are based on setting up a ratio, such as the area of the migrational biotopes to the area of the quarry. Regardless

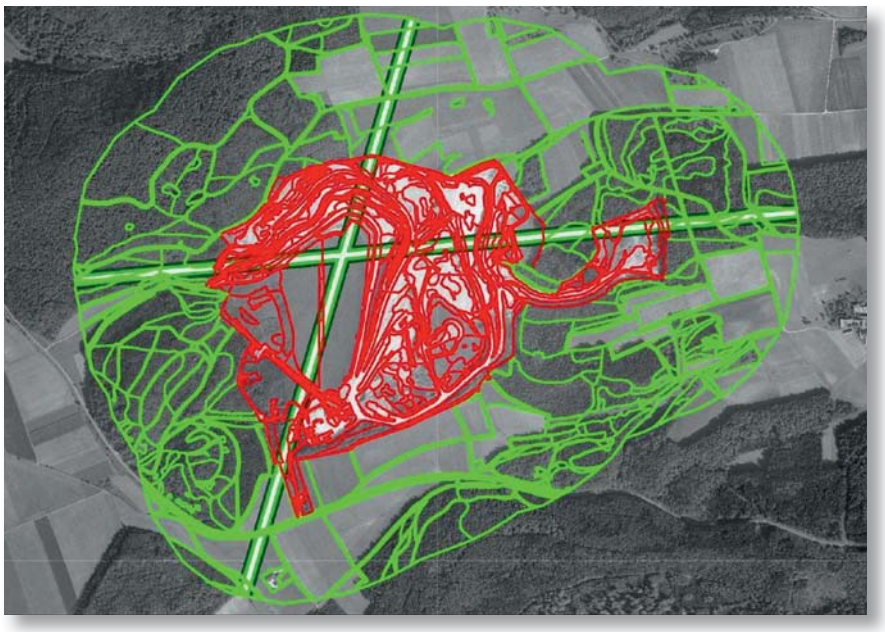

Figure 3: Representation of the location of the "Largest Width/Length" two-line transect

[*)] The totals for the bird species within the quarry and its surrounding area are lower than the identified total as there is some duplication of species.

Table 1: Investigative programme for determining the basic data, classified on the basis of the size of the excavation site (X = Investigation is standard, E = Excavation site, S = Surrounding area, TM = Topographic Map 1:25 000)

Excavation Site/Size	Biotope	Flora	Avifauna	Amphibians	Dragonflies	Butterflies
Very large excavation sites (> 50 ha)	X (E/S)	X (E/S/TM)	X (E/S)	X (E/S)	Optional (E/S)	
Large excavation sites (> 25 to 50 ha)	X (E/S)	X (E/S/TM)	X (E/S)	Optional (E/S)	–	–
Mid-sized excavation sites (10 to 25 ha)	X (E/S)	X (E/S/TM)	Optional (E/S)	–	–	–
Small excavation sites (< 10 ha)	X (E)	X (E/TM)	–	–	–	–

of the statistical reliability these indicators cannot be determined with sufficient accuracy by the transect method. Data acquisition for the entire excavation site and its surrounding area is the method that involves the greatest effort. However, it clearly delivers the best findings that do not contain any uncertainties. Each of the formulated indicators can be calculated without restriction on the basis of this data acquisition. Analysis of the entire excavation site and its surrounding area, with the advantage of a more comprehensive and statistically secured data base, is the recommended method of monitoring despite the greater effort involved.

3.4 Policies for the methodology and scope of the investigations

Recommendations have been compiled for the methodology and scope of the investigations; these contain a graded research programme for the determination of the basic data based on the volume of the excavation site. The scope depends on generally accepted technical standards, but is somewhat reduced. The following groups of species are suggested as being standard: habitats and flora, avifauna, amphibians, dragonflies, butterflies and moths. The coverage is differentiated on the basis of the size of the excavation site (◗ Table 1).

3.5 Defining habitats

The great importance of quarries for the protection of species and biotopes is based primarily on the multiplicity of small-scale interlocking living space and/or development areas for flora and fauna of different ages in the context of space and time. Standardized guidelines were compiled for the boundaries of migrational biotopes and partial habitats in order to facilitate long-term monitoring within a excavation site and comparability between the excavation sites. The following standards were formulated:

- Partial habitats, which cannot be classified as biotope species due to missing or partial flora/vegetation, are systematically classified as "partial habitats".
- Partial habitats that exhibit sufficient vegetation but do not correspond to the prevalent biotope classifications are categorized due to the dominant plant species as societies.
- These classifications are to be employed if an informal classification is possible on the basis of the current biotope codes.

3.6 Development of biodiversity indicators

A central component of the project was the development of a meaningful and practicable set of indicators by which the biodiversity and its dynamics can be measured and evaluated. The current existing national and European biodiversity indicators could only be applied to parts of the project so unique indicators were developed. The potential indicators can be arranged on the basis of three organizational levels: The "Ecological System Level" ("Habitat" indicator set), the "Organism Level" ("Biodiversity" indicator set) and the "Genetic Level" ("Genetic Diversity" indicator set).

The first step was to create 56 indicators, of which a total of 31 indicators are related to the "habitats" indicator set (three to the "habitats" section, nine to the "subsequent utilization" section, five to the "migratory biotopes" section, seven to the "endangered biotopes" section and seven to the "structural diversity and abiotic factors" section). The "diversity of species" indicator set contains a total of 21 indicators. Of these, five are allotted to the "species figures" section, seven to the "population sizes" section, eight to the "valuable species" section and one to the "disruption of characteristic species" section. The "genetic diversity" indicator set is not divided further and contains a total of four indicators. Derivation of the target achievement values turned out to be one of the most critical points during the development of the indicators.

On the basis of extensive data analyses and discussions it was possible to select ten indicators from the total of 56 indicators; these indicators were classified as suitable and were therefore to be tried in the context of a test phase (◗ Table 2). Three of these are contained in the "habitats" indicator set – one indicator from each of the "habitats", "subsequent utilization" and "migratory biotope" sections. The "species diversity" indicator set contains a total of seven indicators, of which four indicators are assigned to the "species figures" section and three indicators are assigned to the "valuable species" section.

The indicators Species Figure Var. 2 and Species Figure Var. 3 can easily be determined and can therefore be used as base indicators. Another 18 additional indicators were selected, but most of them are currently limited in their applicability due to the lack of derivability of the target achievement values. A designation was developed for each of the selected indicators that displayed the indicator as a formula, with a unit and accuracy, objective, monitoring, achievement of objective values and scaling. The value of the indicator was then calculated for the Vohenbronnen quarry.

A guideline was compiled that contains an indicator set specified on the basis of the size of different quarries. This means that different values can be determined within particular indicators depending on the number of groups or species investigated.

3.7 Target achievement values

The derivation of the target achievement values turned out to be a particularly demanding point during the development of the indicators. In spite of the fact that the data

are extensively available from excavation sites, the target achievement values – particularly regarding fauna – cannot be adequately fixed because the data records are too heterogeneous and incomplete despite the extensive data. In spite of their good applicability in principle it was necessary to exclude several of the indicators that have been discussed, at least provisionally, for the reasons listed above. One example of this are the indicators that rely on figures for animal or plant species.

3.8 Local biodiversity action plan

In addition to the indicators a Local Biodiversity Action Plan was compiled for the Vohenbronnen quarry; it consists of a Habitat Action Plan and a Species Action Plan. The creation of a sanction and development plan is one objective of the Local Action Plan; it is to include the different national and local concepts regarding objectives and sanctions. After these objective and measurement concepts had been evaluated Habitat Action Plans were drawn up for "temporary to perennial small waterbodies with periodical wet pioneer and ruderal meadows" and "neglected calcareous grasslands" for the migrating biotope complex of the Vohenbronnen quarry while taking account of the local conditions. Species Action Plans were developed for the following five animal and plant species: the dragonfly species Orthetrum Coerulescens (black tail skimmer), the bird species Crex Crex (corncrake), Perdix Perdix (partridge), Bubo bubo (eagle owl) and Charadrius dubius (little ringed plover), and the plant species Linum Flavum (yellow flax).

3.9 Interfaces for impact regulations and eco-accounts

The project interfaces for impact regulations and eco-accounts were finally compiled and discussed. The indicators that have been developed apply to the operating excavation sites and their respective vegetated and/or re-natured areas and make no direct reference to the planning of extensions. However, several interfaces can be derived: the monitoring for the indicators also serves for quality assurance of the compensation measures from the impact regulation. The intended promotion of re-naturation methods has a direct effect on the method used for compensation measures. Implementation of the indicators can be employed as a means of reconciliation for compensation for the time lag. The indicators also provide important information about the protected species in Europe.

3.10 Transferability

In the context of the development of indicators all the available data were gathered and reviewed for their usability with regard to the different indicators. This extensive examination shows that despite the heterogeneous data, the indicators can be transferred to other non-metallic minerals industries. This is mainly the case because during the project (2007) the indicators were adapted successively from relatively complex ideas and designs to match the level of complexity of indicators developed by the EEA.

The project was also introduced and discussed at a workshop with representatives from companies and associations belonging to other branches of the non-metallic minerals industry. This event showed that for the majority of the companies, the aim of sustaining the biodiversity in excavation sites is classified as an opportunity (and not as a risk). Most of these companies are planning or at least discussing the implementation of sustainability indicators. Nevertheless, it became clear during the workshop that conditions for implementing the indicators and monitoring programmes differ widely between the individual industries and companies. The indicators that were developed to suit the situation at the Schelklingen cement plant seem to be a

Table 2: List of selected indicators

Indicator	Evaluation
"Habitats" Indicator Set	
Habitats section	
◗ Number of Habitats Var. 2	Number of habitats in the excavation sites/Areas of the excavation sites (ha)
Subsequent utilization Section	
◗ Subsequent utilization Var. 7	Areas of the excavation site with subsequent utilization of nature conservation (ha)/ Areas of the excavation sites with subsequent utilization of cultural landscape (ha)/Areas of the excavation sites (ha)
Migratory Biotypes Section	
◗ Surface section of the migratory biotopes Var. 1	Areas of the migratory biotopes of the excavation sites (ha)/Areas of the excavation sites (ha)
"Diversity of Species" Indicator Set	
Species Figures Section	
◗ Species figure Var. 2	Species figures for plant species on the excavation site/Area of the excavation site (ha)
◗ Species figure Var. 3	Species figure for the plant species on the excavation site/Species figure for the plant species in the surrounding area
◗ Species figure Var. 4	Species figure for selected animal groups on the excavation site/Area of the excavation site (ha)
◗ Species figure Var. 5	Species figure for selected animal groups on the excavation site/Species figure for selected animal groups in the surrounding area
Special Species Section	
◗ Percentage of endangered species Var. 5	Percentage of endangered species on the excavation site/Percentage of endangered species in the surrounding area
◗ Figure for endangered species Var. 7	Figure for species on a specified taxoceonisis-related species list/Total species figure for a specified taxoceonisis-related species list
◗ Types of Species Action Plans	Sources and/or individual figures for the types of Species Action Plans

huge advance towards feasible instruments. However, it will still be necessary to make adjustments for different conditions and the approaches that have been shown for biodiversity indicators will have to be tested at different excavation sites.

4 Conclusion

The results and experience from the project show that indicators and the monitoring programmes based on these indicators can be suitable instruments for measuring and evaluating biodiversity and its dynamic in quarries in the non-metallic minerals industry, provided these instruments are adapted to the specific conditions of such excavation sites. The indicators suggested by the European Union do not yet fulfil the required specifications. Clear improvements in this respect were achieved during the course of the project.

Nevertheless, there is still a need for further research. The indicators that have been developed and selected have to pass a trial period at as many different excavation sites as possible (wet and dry excavation, different rocks, sizes and natural environments). It is also necessary to evaluate the achievement of objective values for each indicator.

What actually remains to be done is further differentiation and adjustment of the methods that have been derived so that they can be applied to other plants and companies, and especially to other non-metallic mineral industries with their own specific conditions. However, the results of the project show that it should be possible to develop a general system of indicators to meet local conditions. This should form the focus of future work and professional circles should be included in further development of the project results. The full report about the project's results in German is provided for download on the website www.initiative-nachhaltigkeit.de.

LITERATURE / LITERATUR

[1] Bonn, S.; Poschlod, P.: Ausbreitungsbiologie der Pflanzen Mitteleuropas. Quelle & Meyer (1998), 404 S.

[2] EEA (European Environmental Agency): Information for improving Europe's environment, 1997, http://themes.eea.eu.int/Sectors_and_activities/transport/indicators

[3] Basten, M.: Investitionen, Rohstoffe und Naturschutz – Aspekte nachhaltiger Entwicklung am Beispiel der Zementindustrie in Nordrhein-Westfalen. ZKG International 54 (2002) No. 3, S. 54 ff.

[4] BDZ/VDZ (Bundesverband der Deutschen Zementindustrie e.V./Verein Deutscher Zementwerke e.V.; Hrsg.): Naturschutz und Zementindustrie. Projektteil 1: Auswertung einer Umfrage. Bearbeitet von Tränkle, U./Röhl, M., Verlag Bau+Technik GmbH, Düsseldorf 2001, 40 S.

[5] BDZ/VDZ (Bundesverband der Deutschen Zementindustrie e.V./Verein Deutscher Zementwerke e.V.; Hrsg.): Naturschutz und Zementindustrie. Projektteil 2: Literaturstudie. Bearbeitet von Tränkle, U./Offenwanger, H./Röhl, M./Hübner, F./Poschlod, P., Verlag Bau+Technik, Düsseldorf 2001, 113 S.

[6] BDZ/VDZ (Bundesverband der Deutschen Zementindustrie e.V./Verein Deutscher Zementwerke e.V.; Hrsg.): Naturschutz und Zementindustrie. Projektteil 3: Management-Empfehlungen. Bearbeitet von Beißwenger, T./Tränkle, U./Hehmann, M., Verlag Bau+Technik, Düsseldorf 2002, 26 S.

[7] Tränkle, U.: Vergleichende Untersuchungen zur Sukzession von Steinbrüchen und neue Ansätze für eine standorts- und naturschutzgerechte Renaturierung. Poschlod, P./Tränkle, U./Böhmer, J./Rahmann, H. (Hrsg.): Steinbrüche und Naturschutz, Sukzession und Renaturierung. Umweltforschung in Baden-Württemberg, ecomed (1997), 1–327.

[8] Böhmer, J.; Rahmann, H.: Faunistische Aspekte der Sukzession, der Rekultivierung und des Naturschutzes in Steinbrüchen Südwestdeutschlands. Poschlod, P./Tränkle, U./Böhmer, J./Rahmann, H. (Hrsg.): Steinbrüche und Naturschutz, Sukzession und Renaturierung. Umweltforschung in Baden-Württemberg, ecomed (1997), S. 329–485.

[9] Rademacher, M.: Untersuchungen zur Vegetationsdynamik anthropogener Kiesflächen am Oberrhein unter Berücksichtigung landschaftsökologischer und naturschutzfachlicher Belange. – Inaugural-Dissertation, Fakultät für Biologie der Albert-Ludwigs-Universität Freiburg i.Br., (2001), 311 S. + Anhang.

[10] Raw Materials Supply Group: EU extractive industry: SDIs for 2001. A report from the Raw Materials Supply Group. European Commission, (2001), 4 pp.

[11] Raw Materials Supply Group: EU Non-Energy Extractive Industry Sustainable Development Indicators 2001-2003. A report from the Raw Materials Supply Group. European Commission, (2006), 30 pp.

[12] Bennett, N.: Sector Analysis: Minerals and aggregates (2002), 10 pp.

[13] Fernández, P.; Möllerherm, S.: Bildung und Bewertung von Indikatoren für eine nachhaltige Entwicklung bei der bergmännischen Gewinnung nicht-energetischer mineralischer Rohstoffe in Deutschland. Im Auftrag der Bundesanstalt für Geowissenschaften und Rohstoffe. Institut für Bergbaukunde der Rheinisch-Westfälischen Technischen Hochschule Aachen, 2004.

[14] Gilcher, S.; Tränkle, U.: Steinbrüche und Gruben Bayerns und ihre Bedeutung für den Arten- und Biotopschutz. Hrsg.: Bayerischer Industrieverband Steine und Erden e. V., Bayerisches Landesamt für Umwelt, 2005, 199 S.

[15] Tränkle, U.; Beißwenger, T.: Naturschutz in Steinbrüchen. Naturschutz, Sukzession, Renaturierung. Schriftenreihe der Umweltberatung im ISTE Baden-Württemberg 1, (1999), 83 S.